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POST-WAR PRESSURES IN THE CURRICULA. *H. M. Crothers, Second Vice-President* 81
LETTER TO THE EDITOR. *Fred E. Ayer* 82
AMERICAN COUNCIL ON EDUCATION 83
CONFERENCE ON HUMANITIES 83
REPORTS ON CONFERENCES AT CINCINNATI MEETING: 84
AGRICULTURAL ENGINEERING 84
CHEMICAL ENGINEERING 84
ELECTRICAL ENGINEERING 89
ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY 89
ENGINEERING SCHOOL LIBRARIANS 93
ENGLISH 94
EVENING ENGINEERING EDUCATION 95
INSTRUCTIONAL METHODS AND COMPREHENSIVE EXAMINATIONS 96
MATHEMATICS 97
MECHANICAL ENGINEERING 98
MECHANICS 99
MINERAL TECHNOLOGY 100
PHYSICS 101
RELATIONS WITH INDUSTRY 102
PROFESSIONAL REQUIREMENTS AND GROWTH OF THE TEACHING STAFF IN CHEMICAL ENGINEERING. *C. F. Bonilla* 105
ENGINEERING—A PROFESSION. *L. M. Gram* 114
ARMED FORCES INSTITUTE AND THE PROBLEM OF CREDITS EARNED UNDER THIS AND A.S.T. PROGRAM. *W. R. Bryans* 119
WHAT CURRICULUM AND PROCEDURE FOR THE RETURNED SERVICE MAN WITH PARTIAL UNDERGRADUATE EDUCATION? *J. S. Prior* 125
AMPLITUDE OF A STEADY FORCED VIBRATION. A SHORT METHOD OF EVALUATION. *H. C. Perkins* 128
WAR TIME CONVERSATIONS. *Major A. J. Stowe* 130
EDUCATION FOR POST-WAR INDUSTRY. *R. E. Orton* 135
THE CARNEGIE SOCIAL RELATIONS PROGRAM. *Glen U. Cleeton* 146
A.S.E.E. SUMMER SCHOOL FOR TEACHERS OF ENGINEERING DRAWING, 1945 155

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Post-War Pressures in the Curricula

By H. M. CROTHERS

Second Vice President of the Society

Engineering education has long had a surplus of material claiming and deserving attention in the four-year curricula. This condition of internal pressure has some real advantages. Competition for time and place undoubtedly has had beneficial effects in teaching methods. Few engineering students have had occasion to complain that the subject matter was spread too thin. From many standpoints this is a healthy condition.

This condition also has its disadvantages. The pace may become too rapid, there may be too little time for that digestion of subject matter which is so essentially a part of real education. Competition is not always the most reliable way of testing values. For the immediate post-war period there is reason to expect an increase in this surplus of material and in the resultant pressure for time and place in the curricula. We shall meet this problem better if it does not catch us unaware.

New war-time developments have been made in many fields of engineering and in many engineering practices of industry. Each teacher can name some in his own field. Electrical engineers, for example, have heard much about ultra-high frequencies and radar, industrial electronics, servo-mechanisms, and others. As such new developments are fully released to the public, each one will raise the question as to its place in engineering education.

The claims of these new developments for attention may be rather strongly supported. Many engineering teachers have had a part in the developments and their interests will be keen in these fields. Engineering students and the public will expect engineering courses to be "up to date." There is more news interest in a spectacular engineering development made during the war than there is in a basic scientific discovery of 100 years ago. Uncontrolled competition between these two is likely to be disastrous. Engineers working with these new developments will be seeking trained assistants and will be seeking recognition of their fields. A recent conference of engineers on Statistical Methods of Quality Control rather insistently raised the question concerning the training of men in this subject. Safety engineers are discussing with renewed vigor the need for courses in Industrial Safety.

At least some of the claims may be fully legitimate. There can be little doubt that the war-time engineering developments will bring about some necessary and justified adjustments in the curricula.

In the presence of this increased internal pressure, one danger is that the yielding may be in the wrong place. We may allow our curricula to become top heavy. That is, we may provide for additional topics in advanced engineering applications at the expense of the basic scientific subjects. The popular interests, the war-time practices of training for immediate objectives rather than long time objectives, and other influences will be pulling in this direction.

To counteract these influences there is the considered judgment of engineering teachers that: "Undergraduate curricula should be made broader and more fundamental through increased emphasis on basic sciences and humanistic and social studies. . . Some of the advanced technical subject matter now included in undergraduate curricula should be transferred to the post-graduate period where it may be pursued with a rigor consistent with preparation for engineering specialization." This statement was given prominence in the 1940 Report on Aims and Scope of Engineering Curricula, and it was reaffirmed in the 1944 Report on Engineering Education after the War.

It is not always easy to hold to principles in the face of pressure. As this problem is met by each institution in its own way, the Sections and Branches may find it of service to call attention to the principles agreed to and stated through the activities of this Society. Each department and each individual teacher will decide to some extent how this question is to be met.

Letter to the Editor

By FRED E. AYER

Dean, Engineering College, University of Akron

My article on Analytic Geometry in the April issue of the S.P.E.E. *Journal* had two objectives. One, to start an argument, and two, to clarify my own thinking. Number one succeeded beyond my fondest expectations. Number two left my intellectual waters holding more than a normal amount of solids in suspension.

The pros and cons were divided about the same as in my own institution, the mathematicians being cons and the engineers pros. One engineer was so enthusiastically pro that he replied thus: Hallelujah: Amen! AMEN!. However, there were two engineering teachers who disagreed thoroughly. Because of the brevity of the article, misunderstandings were to be expected. While the applications of many of the formulas in Analytics were questioned, it was not inferred that none of those should be taught, but rather that the few necessary ones might well be made a part of the visualization of algebraic equations while teaching algebra. Furthermore, the general equation of a straight line and its slope equation provide, in my experience, all the foundation required for all straight line problems. Also, the practical application of the division of a line into a given ratio of parts is nothing more than the application of the old theorem in plane geometry that a line parallel to the base of a triangle divides its sides proportionately.

I think the gist of the whole controversy settles here. The mathematicians insist that it requires four years of training to produce even an embryo in the mathematical field, and three more years and a Ph.D. are necessary for a creditable finished product. The Engineers insist that four years are needed to fit a student to start on a beginning engineering job and a five year requirement is being continually advocated. Then how can we expect to produce both a mathematician and an engineer in the limited time required to train either one? Such attempt can only result in a hybrid such as follows when we try to train both a chemist and an engineer in the same length of time required to train either. As we grow older and teach longer, we tend to forget the immature status of our entering students and attempt to teach graduate courses to undergraduate students.

In conclusion, nothing has been accomplished by the article because each side is like the Scotch minister who said, "I hae an open mind, but I hae yet to find the mon who cood change it."

American Council on Education

In place of its annual meeting the American Council on Education called together a conference of representatives of its constituent organizations in Washington on May 4 and 5, 1944.

This was probably the first meeting of the kind—including representatives of practically all group organizations kindred in scope and purpose to the Society for the Promotion of Engineering Education.

A half day was devoted to the discussion of proposals for compulsory military training, with special reference to their bearing on education and public finance.

A half-day session was also given over to group conferences on professional education in relation to general and liberal education. The conference dinner was addressed by Dr. Archibald MacLeish, Librarian of Congress, on measures being taken by the Allied armies to safeguard and preserve cultural treasures in Europe.

A third half-day session was devoted to the consideration of legislation for veterans' education, with particular reference to the agencies of its administration. The conference passed resolutions strongly supporting the use of established federal and state public educational agencies for the administration of this post-war problem.

Conference on Humanities

Through the generosity of the Rockefeller Foundation, the S.P.E.E. has received a grant of $1800 to cover the expenses of a conference on the humanities and technology which is to be held under the chairmanship of Dr. Frank Aydelotte, Director of the Institute of Advanced Studies, in the early fall.

The proposal to include this conference in the program of the Cincinnati meeting was set aside at the suggestion of the Rockefeller Foundation.

The plan now in view is to hold a one-day conference—possibly at Princeton, N. J.—in which a representative group of leading authorities in several fields of the humanities and in various branches of science and engineering will express their carefully considered views on the relations between the two fields. A transcript of the discussion will be made and edited and the report given wide circulation in educational circles.

WILLIAM E. WICKENDEN

Reports of Conferences

Cincinnati Meeting, June 22-25, 1944

Agricultural Engineering.—Engineering educators are becoming increasingly interested in the field of agricultural engineering. The pressing need for better engineering in the agriculture of all countries of the world is becoming increasingly evident.

The first paper at the Agricultural Engineering Conference was presented by J. B. Davidson of Iowa State College. Dr. Davidson is frequently referred to as the dean of agricultural engineering educators in this country. In his paper Dr. Davidson defines the field of agricultural engineering, describes accomplishments and points out future trends. He feels that all engineers should be interested in the proper developmeent of this branch which is so closely related to perhaps the most fundamental activity of mankind, the production of food.

A problem facing agricultural engineering educators in many colleges and universities, as well as members of accrediting committees of the E.C.P.D., is that of accrediting of curriculums in Agr. Eng. Dean R. A. Seaton of Kansas State College presented a most complete and thought-provoking paper on "Accrediting of Agricultural Engineering Curriculums." He concludes his paper with a general specification of the type of agricultural engineering curriculum which would fully merit accreditization by E.C.P.D.

This conference on agricultural engineering was attended by twelve heads of agricultural engineering departments from various state colleges and universities; H. T. Heald and D. B. Prentice representing E.C.P.D.; Professor R. H. Driftmier, President, A.S.A.E.; engineering deans and agricultural engineers engaged in industrial activities.

Considerable discussion followed the presentation of the two papers. There was universal agreement that much benefit would result from continuing agricultural engineering conferences at S.P.E.E. meetings looking toward further clarification of accrediting curriculums and other matters related to agricultural engineering, of common interest to all engineering educators.

L. J. FLETCHER,
Chairman

Chemical Engineering.—Two conferences, a dinner meeting, and a short business meeting comprised the program for this division. Although the average attendance, around thirty delegates, was slightly less than at past meetings, a full program of varied and stimulating topics aroused much informal discussion, both inside and outside of the conference rooms. Visits by individual members to the chemical engineering laboratories of the University of Cincinnati were a welcome feature of the convention.

At the annual dinner meeting, E. S. Allen, patent attorney, Cincinnati, spoke on "Patents and the Chemical

Engineer." He dwelt on the present trends in judicial decision as to patents, tracing the present attitude of the Courts toward patents to a hostility which grew out of the trust-busting era of Theodore Roosevelt. That patents are a "good thing," and are necessary for free enterprise, seems again to be realized as the pendulum of interpretive decision swings backward. At the close of the meeting, Mr. Allen graciously answered numerous questions put to him by members from the floor.

Preceding the second afternoon conference on Saturday, June 24, Chairman R. A. Morgen (Florida) called to order the annual business meeting. The minutes of the Chicago meeting appearing in the JOURNAL OF ENGINEERING EDUCATION, **34**, 124–7 (Oct. 1943) were approved as published therein. The Treasurer reported that expenses for the year amounted to only $5.81, thus leaving a balance of $56.99 as of June 22, 1944, and recommended that no special assessment of members be made this year.

The nominating committee, composed of J. H. Koffolt (Ohio State), W. A. Koehler (West Va.), and G. W. Gleeson (Oregon State), preseented the following slate of officers for the year 1944-45:

Chairman—C. O. Miller (Case),
Vice-Chairman—G. W. Gleeson (Oregon State),
Vice-Chairman—C. P. Baker (Northeastern),
Secretary-Treasurer—E. M. Schoenborn (Delaware).

These nominees being unopposed, the Secretary was instructed to cast one ballot for the slate.

Under old business, Chairman Morgen called attention to the accelerated program (similar to that of the A.S.T.P.) which had been drawn up and submitted to members whereby, it was hoped, men would be better trained for industry. Owing to curtailment of the A.S.T. Program all over the country, and the recent sudden change in Selective Service regulations, this matter of a uniform curriculum was tabled.

Under new business, discussion arose concerning the possibility of again holding, as soon after the end of the war as practicable, a Summer School for Chemical Engineering Teachers. It was suggested that the new Chairman appoint a committee to look into this matter so that plans could be drawn up and reported on at the next annual meeting. R. N. Shreve (Purdue) suggested that such a program be held at or near some conveniently located summer resort, since such a location would attract a large number of members.

C. O. Miller (Case) suggested that those members attending the fall meetings of either the American Chemical Society or of the American Institute of Chemical Engineers meet together to discuss plans for the next S.P.E.E. program.

J. H. Koffolt (Ohio State) recommended that the possibility of again reproducing and binding the collected papers of these meetings in book form be investigated. R. N. Shreve (Purdue) stated that this might not be possible, owing to the current paper shortage, but agreed to discuss the matter with Mr. S. L. Tyler, Executive Secretary, A. I. Ch. E., to see what could be done.

G. W. Gleeson (Oregon State) and A. B. Newman (C. C., N. Y.) presented the following resolutions for consideration of the group:

A. WHEREAS the meetings of the Chemical Engineering Division of the

fifty-second annual meeting of the Society at Cincinnati, Ohio, June 22–25, 1944, are declared highly successful,

THEREFORE BE IT RESOLVED that, first, a vote of appreciation and thanks be extended to the people of Cincinnati, and particularly to the local committee, for the very evident hospitality and excellent provision of facilities.

SECOND, that a vote of thanks be extended to all individuals who participated in the program, especially to those who were not members of the division but were willing to attend the meeting to present viewpoints other than those of teachers of engineering.

THIRD, that a vote of appreciation be given to the officers of the division for the excellent program which was prepared and for their activities during the past year.

B. WHEREAS word has been brought before the Chemical Engineering Division of S.P.E.E. to the effect that the E.C.P.D. has referred the matter of accrediting of Technical Institutes to the constituent members for their decision concerning such an accrediting program,

BE IT RESOLVED that it is the informal opinion of the Chemical Engineering Division of S.P.E.E. that E.C.P.D. is the only logical organization to undertake the accrediting of the Technical Institutes and that E.C.P.D. should be encouraged to foster and control this program.

THEN, BE IT FURTHER RESOLVED that, if action is taken by the E.C.P.D. toward accrediting the Technical Institutes, or courses or groups of courses corresponding to that level of instruction, it is the informal opinion of the Chemical Engineering Division of the S.P.E.E. that such accrediting be limited to those Institutes or curricula which are definitely a part of and under the control of Engineering Colleges or Schools.

BE IT FURTHER RESOLVED, that the Secretary of the Division be instructed to bring this informal expression of opinion to the attention of the Councils of S.P.E.E. and A. I. Ch. E.

Upon motion of T. G. Dixon (Pratt), seconded by J. H. Koffolt, the above resolutions were unanimously accepted and approved.

"Chemical Engineering in the Post War Period."

W. J. Huff (Maryland), "Service and Support of Post War Chemical Engineering Education."

A. B. Newman (C. C., N. Y.), "Current Problems of the Chemical Engineer."

R. L. Copson (TVA), "The Chemical Engineer in TVA."

R. B. Wittenberg (International Minerals and Chemicals Co.), "Post War Chemical Engineering Education from the Standpoint of the User of Chemical Engineering Talent."

R. F. Mehl (Carnegie Tech.), "Training of Foreign Engineers."

F. G. Deutsch (Consulting Engineer), "Professional Ethics and the Unionization of Professional Workers."

Chairman R. A. Morgen (Florida), on opening the conference, called attention to the many serious problems facing the teacher of chemical engineering, not only at the present time but especially in the period following the war. He said he hoped that the papers to be presented would stimulate active discussion and promote clear thinking upon some of the vital issues before us. In this way many of the problems and methods for their solution might be crystallized.

Among the many problems and changes resulting from the war which the colleges may face, W. J. Huff (Maryland) mentioned the possibility of unpredictable enrollments, a system of heavy taxation, and a probable continuation of the twelve-month program. A staff capable of meeting rapid changes in curriculum and teaching

methods to meet specific needs and participating in direct service to local industries should have no fear of survival or support. In the discussion by Koffolt (Ohio State), Gleeson (Oregon State) and Koehler (W. Va.) which followed, a plea for return to the nine or ten month program was advocated to permit students to take summer jobs in industry. Dean Newman (C. C., N. Y.) agreed on the general usefulness of visual aids in teaching, and stated that the U. S. Office of Education was preparing motion picture films which might be of use in the classroom.

In an informal discussion of the current manpower problem, Dean Newman outlined briefly some of his activities in connection with Selective Service. He warned against the unrestricted propagation of the so-called Technical Institute which might result upon passage of bills appearing in Congress; he advocated accrediting of such Institutes only if they are a part of and under the control and guidance of recognized engineering schools.

Mr. G. L. Bridger, in giving the paper of Dr. Copson (TVA), outlined the nature of the work being done at Muscle Shoals and the way in which chemical engineers have contributed to the success of that agency. He stressed particularly the need for men with advanced degrees, and of those types of engineers who could get along well with others.

Discussing further the viewpoint of the user of chemical engineering talent, R. B. Wittenberg (Int. Minerals) pleaded for a "liberalizing" of the engineering course. The ability to write and speak correctly, to sell one's ideas, to understand something of management and organization, of costs and accounting—these, in addition to a sound technical training, are vitally necessary in the chemical engineer who wishes to advance into executive and administrative responsibilities.

R. F. Mehl (Carnegie Tech.) next outlined briefly the plan for training foreign students in this country as proposed by the Federal Economic Administration. He emphasized that the plan was not one of engineering education, but rather a program in industrial technology, and that such a venture would create much permanent good will for our country throughout the world.

In a stimulating paper on unions as they relate to professional men, F. G. Deutsch outlined the laws relating to unionization and the types and aims of unions. He dwelt upon some of the ethical concepts as related to unionism, indicating briefly the attitudes of some of the national societies towards this timely topic. The paper contains a bibliography of 54 references on the subject.

The conference closed with a general discussion of the Technical Institute. R. S. Tour (Cincinnati) indicated the growing need for such schools in the training of certain workers in our present industrial system, but agreed with Dean Newman that their control should not get out of the hands of our engineering colleges and universities. It was suggested that our curricula might well be adjusted to give training of such sub-professional character to the many individuals desiring it, without lowering the standards of work in the collegiate level. E. M. Schoenborn (Delaware) called attention to the treatment of this subject in the Report of the Committee on Engineering Education After the War of S.P.E.E., appearing in the JOURNAL OF ENGINEERING EDUCATION, **34**, 589–614 (May, 1944).

R. C. Ernst (Louisville), "The Cooperative Course in Chemical Engineering."

George Löf (Colorado), "The Chemical Engineering Practice School."

J. E. Vivien (M. I. T.), Discussion of paper by Löf.

H. P. Simons (W. Va.), "The Use of Scale Models in Teaching Chemical Engineering Plant Design."

G. W. Gleeson (Oregon State), "Random Thoughts on Teaching Chemical Engineering."

R. M. Boarts (Tenn.), "Chemical Engineers for the Smaller Industries."

The second conference opened with a discussion of the copoerative system of engineering education by R. C. Ernst (Louisville). He pointed out the advantages and disadvantages of the cooperative plan, and gave a detailed description of the course at Louisville. Ernst made a strong plea for greater integration of course content and inculcation of the professional attitude in our engineering students.

The practical training of chemical engineering students was next discussed from the standpoint of the Practice School by Löf (Colorado) and Vivien (M. I. T.). The programs at the University of Colorado and at Massachusetts Institute of Technology appear to be unique in this respect, although the latter is primarily a graduate curriculum.

A series of slides showing the use of models in teaching plant design illustrated the paper by H. P. Simons (W. Va.), who pointed out the distinct advantages to be gained from such visual aids in the saving of drafting time, elimination of drawings, and in the creation of enthusiasm in the student. F. C. Vilbrandt (V. P. I.), discussing this paper, showed several interesting plant models constructed by students in his classes.

G. W. Gleeson (Oregon State) offered a stimulating personal philosophy of chemical engineering teaching which touched upon many diversified problems faced, not only by the student, but by the instructor as well.

Owing to the late hour, the paper by R. M. Boarts (Tenn.) was read by title only. It called attention, however, to the wider base of employment needed for chemical engineers if large post war enrollments develop, and to the significance the smaller industries will attain because of their position in the national economy.

After a brief general discussion concerning plans for the next annual meeting, the conference adjourned.

E. M. SCHOENBORN
Secretary-Treasurer

The newly elected officers for the **Electrical Engineering** division of the S.P.E.E. for the year June, 1944 to June, 1945 include the following:

Chairman—Professor A. D. Moore, University of Michigan, Ann Arbor, Michigan.

Vice-Chairman—Professor A. B. Bronwell, Northwestern University, Evanston, Illinois.

Secretary—Colonel F. H. Pumphrey, A.S.T.P. Division, Army Service Forces Headquarters, Pentagon Building, 1C666, Washington, D. C. (Rutgers).

A. B. BRONWELL

Engineering Drawing and Descriptive Geometry.—

Opening Conference, Thursday June 22, 2:00 P.M.

Professor W. E. Farnham, Chairman, presided, forty-four members and

guests present. In the absence of Professor Tozer, Professor W. J. Luzadder was appointed acting secretary and after making a few general remarks, the chairman introduced Professor B. M. Aldrich of Oklahoma A and M College who spoke on "The Isometric Approach to Descriptive Geometry" and Professor John T. Rule of the Massachusetts Institute of Technology who presented a paper on "Three Dimensional Drawings." Professor Rule commented in general before projecting a set of slides made to teach descriptive geometry. At the end of the discussion, Professor Rule explained and demonstrated the process of production of three dimensional slides and prints. Sample prints were fastened to the walls of the room for inspection by division members and envelopes with sample slides and viewers were passed to each member of the audience.

Professor C. V. Mann suggested that a committee be appointed to discuss methods of teaching Descriptive Geometry. In discussing this Professor Porter remarked that no attempt should be made to standardize a particular method of teaching descriptive geometry, but we should be open minded to receive all new methods of presentation. He suggested that first an attempt be made to standardize descriptive geometry nomenclature. Professor Mann moved that the Drawing Division set up a committee for the year 1944–45 to study, with a view to subsequent standardization, the notations and nomenclature for descriptive geometry and to report at the next annual meeting of the Division. This was duly seconded and carried without a dissenting vote. No action was taken on Dr. Mann's earlier suggestion of teaching methods. The meeting ended with a general discussion of the use of visual aids for teaching descriptive geometry.

Dinner Meeting, Thursday, June 22, 6:30 P.M.

The annual Division Dinner was attended by 50 members and guests. Professor C. B. Hoffman, Chief Engineer and Technical Adviser of Sperti, Incorporated, of Cincinnati, gave an interesting illustrated talk, "The Earth Belched Forth Fire." This was concerned with the spectacular formation and eruption of Paracutin, Mexico's most recent volcano. Following his talk, opportunity was afforded to ask questions, which many of the Division did. Professor H. M. McCully, chairman of the nominating committee, presented the following proposed slate of officers of the Division for 1944–45 who were duly elected:

Chairman—Justus Rising, Purdue University.

Secretary—J. Lawrence Hill, Jr., The University of Rochester.

Retiring Chairman—Walter Farnham, Tufts College. Replacing R. P. Hoelscher.

Ivan L. Hill, Illinois Institute of Technology for term of 5 years replacing R. W. French. Other members of committee are:

F. M. Porter—University of Illinois—4 years.

E. C. Willey—Oregon State College—3 years.

G. M. Phelps—Rensselaer Polytechnic Institute—2 years.

F. A. Heacock—Princeton University—1 year.

Journal of Engineering Drawing—W. E. Street, Agricultural and Mechanical College of Texas, Editor.

J. M. Wood, Kansas State College, Business Manager.
J. N. Arnold, Purdue University, Advertising Manager.
Editor of T-Square Page—
H. C. Grant, University of Wisconsin at Milwaukee.

Friday, June 23, 8:00 P.M.

About 50 Division members attended this session presided over by the new chairman, Professor Rising. He introduced Kenneth W. Vaughn of the Carnegie Foundation who spoke on the basic and fundamental principles of testing. His talk was followed by a presentation by Professor M. R. Graney of Purdue University of various kinds of objective type examination questions that can be used in engineering drawing. The highlights of these two papers were summarized by Professor J. L. Hill, Jr., of The University of Rochester, who also presented the report of the National Drawing Test Committee. It was regularly moved and seconded that "The Division here assembled formally approves the work and efforts of the Test Committee to date and authorizes them to proceed with the necessary steps to validate the items and to prepare a final test form." This was passed without a dissenting vote.

Summary of Meeting
Symposium on Tests

In making the report of the Test Committee, as is my part in the program, I should like to say that the committee has already reported, at least in part. Our plan was to have Dr. Vaughn discuss the basic principles of testing, followed by Dr. Graney giving some concrete examples of various kinds of problems or objective questions that might be used.

From these two talks, we hoped you might become intrigued with the possibilities of using objective tests in your normal class room procedures and would come to appreciate their real significance and usefulness. We anticipated, also, that these two presentations would be a fitting introduction to the very brief statement of what your Test Committee has done so far. Before making this statemeent and asking for your approval, I should like to summarize for you, as best I can, the highlights of the two preceding speakers' discussions.

You have heard Dr. Vaughn state that one of the fundamental principles of making a test is to know first what it is you want to find out or measure. That holds true for your class room tests as well as for any nationwide standardized test. He also differentiated between objective and subjective tests and has stated that one of the chief advantages of the former is that it eliminates errors in judgment of correction. It also permits comparative study of answers year by year and section by section at any given time.

Another advantage lies in the speed and ease of correction, which for large classes these days of acceleration is worth consideration.

Dr. Vaughn also has made it clear that no test made by an outside agency can do as well for an institution as one made by that school or itself. I am glad that he emphasized this fact, for it should be understood that the Division's test, about which I shall comment briefly in a moment, is not intended in any way to replace your own examinations.

We had hoped that you would get from this meeting some new ideas and might become actively interested with the possibilities of using objective tests

in your class room. They are no panacea for all your testing woes, but they can help in numerous ways.

Let me illustrate with two situations from our recent experiences at the University of Rochester wherein objective type examinations in Engineering Drawing were of particular value. Last July, just about one year ago, there were registered in our Drawing classes nearly 600 Navy V-12 students, about eight times as many as we had ever had in civilian days. During the rather hectic days of registration more than 100 students were registered for a section where the room capacity was only 40. This was duplicated in several instances with the net result that seven classes totalling about 200 men were subsequently given during the evening hours of 7:00 to 9:50. This was in itself bad enough but when the final examination time rolled around in late October, the registrar's office decreed that all examinations would be given in one or more of three places, no one of which was a drafting room. The use of drafting equipment was entirely impossible, but we were fortunate in having used objective type examinations before and so were able to build a final exam that very adequately served the purpose. Sketching was resorted to instead of instrument drawings. By using special answer blanks for most of the questions, we were able to score the six hundred in a relatively short time.

The second situation occurred during this past term when one of our instructors seemed to be less exacting in the quality of work demanded of his students. In spite of tactful and diplomatic suggestions given, the class still remained far behind the others in quality and performance. We figured that the mid-term examination could be so designed that this particular class would be placed in its true relative position with the other sections, at least on part of the examination. By a careful and judicious selection of questions, this was done with the result that the instructor recognized his own shortcomings and promptly took steps to remedy the situation. Everybody, including the students, benefited by this experience, which could not have been accomplished by the usual essay or problem type of examinations alone.

Dr. Graney has shown you on the screen a variety of kinds of questions that can be made objective. These were deliberately chosen from various areas of engineering drawing study and are in addition to questions involving multiple choice answers of words or phrases. Both he and Dr. Vaughn have indicated that true-false questions are the least reliable of any that might be developed. Dr. Graney also defined for us the two terms "reliability" and "validity." The latter term is applied to the degree with which a test or test item really measures what it purports to measure. The term "reliability" refers to the degree of consistency with which the same item or test measures a particular trait. Reliability may also be applied to the consistency with which we as instructors will grade the same question or problem on all papers, or that several of us will grade alike on one paper; statistical measures of reliability can be determined in a number of ways, but in all, the higher the value, the better the question is for separating and spreading the good from the poorer students.

Well, so much for the resumé and now a brief statement of what your test committee has done. Early in the year, Dr. Mann, the chairman, met in Chicago with Professors Rising,

McCully and Spencer and there talked over the general duties and responsibilities of the committee. This was followed by a two day meeting in April at Purdue University of a larger number of committee members including Dr. Mann of Missouri School of Mines, Professor Thomas of Ohio University, Professors Rising and Graney of Purdue, Professor Vierck of Ohio State and myself. Professor Street of Texas A. & M. could not come, but sent some sample tests and materials and Professor Arnold of Purdue served as proxy for him.

After considerable preliminary discussion it was agreed that the committee could best prepare a comprehensive test in engineering drawing by developing first a series of unit tests graded as to difficulty. The ultimate objective of the Division's test would be to serve a three-fold purpose: one, as a means of classifying incoming students for the purpose of sectioning in accord with prior knowledge and ability, two, to determine the level of entrance (or possible exemption) of former A.S.T.P., E.S.M.W.T. or returning service men who have had prior college work in engineering drawing and three, to serve as a general achievement test for students who have completed a college course in engineering drawing. In no sense of the word is it intended to have this test serve as a substitute for your own final examinations, but it could be used as a means of comparing the results of your teaching with other schools of similar size and comparable student body.

The proposed test is not intended to duplicate the efforts of Dr. Vaughn and the SPEE-ECPD-Carnegie Foundation testing program. That is primarily for prediction of probable success in engineering, whereas ours is designed for measurement of first year achievement. What overlapping there may be is unavoidable and of no serious consequence.

At the Purdue meeting of the Committee, a selection of material (by chapter headings of text books) to be covered was decided upon, with which for the moment you are probably not too concerned. This material was further grouped into so called units of testing, one of which deals with the principles and practices of orthographic projection. A test covering this unit has been prepared, which in its entirety will probably take about thirty-five minutes to administer. Five or six other units are to be developed, each taking about the same time to give. The best items, subsequently determined by statistical analysis, will be taken from each unit to make a composite or comprehensive test which, covering the entire field as we have defined it, should take about two hours for administering.

Dr. Vaughn and the Carnegie Foundation have graciously agreed to help us in validating our test item. To do this, we shall need the cooperation of many engineering schools and college drawing departments. It is expected that by January 1945 we shall have all six or seven units ready for actual use. If you agree to cooperate, and have let us say 140 students in your drawing classes at that time, you will be sent 20 copies each of the seven units. These you will be asked to pass out at random and since each unit is designed for only 35 or 40 minutes, the whole test can be given in that length of time. These efforts, duplicated in other schools, we hope will result in at least 500 students taking each of the seven unit tests, or 3500 in all. This should provide sufficient responses for

adequate statistical analysis of each item. From these results, the final form of the comprehensive examination will be developed. This too will have to be constantly refined and rebuilt, but that is yet another problem.

Now in order that the whole report may be put to you for discussion, I move, Mr. Chairman, that the Division here assembled formally approves the work and efforts of the Test Committee to date and authorizes them to proceed with the necessary steps to validate the items and to prepare a final test form.

(This was passed without a dissenting vote.)

J. LAWRENCE HILL, JR.

Engineering School Librarians Committee held two informal discussion meetings at the Cincinnati Conference, June 22, with an attendance of 17. The presence of several librarians from Ohio and Michigan was particularly gratifying, as previous activity had been limited largely to librarians from eastern schools. Widespread interest in the group is evidenced however by the forty replies from all over the country to the preliminary announcement of the meeting.

William H. Hyde (Cornell) presided at the morning discussion on the qualifications, training, and status of the postwar engineering school librarian. The problem of better provision for the training of engineering librarians in library schools was discussed, but it was emphasized that the librarian has a definite obligation also to extend his subject knowledge through continuous study within the engineering school itself. Closer contact with the instructional program was recommended.

The afternoon discussion centered around the formulation of aims and policies. Two brief definitions were drawn up as follows:

1. The *place of the engineering school library in the instructional program* is to impart to every student the vital knowledge of how to use sources and tools of engineering information.

2. The *engineering school librarian* should have the minimum training required for the instructing staff, and competent professional knowledge of both technical subject matter and library practice.

Miss Helen Focke (Case School of Applied Science) reported on the symposium of technical library techniques held during the spring meeting of the American Chemical Society. Mr. McClintock (West Virginia) commented on the fact that this symposium attracted an audience of around five hundred chemists and librarians. (It is hoped that a similar symposium may be arranged for our next S.P.E.E. meeting.)

Miss Granville Meixell (Columbia) repeated her survey report on the instruction of engineering students in library usage and research. Sixteen schools are doing special training through the library; other schools are seeking ways and means. Miss Meixell and her subcommittee plan to work out outlines of procedure for various types of engineering schools.

Professor Nugent (R. P. I.) reminded the group that the engineering student must have interest in literature and humanities as well as science and technology. Miss Focke was appointed chairman of a subcommittee on the humanities aspects of the engineering school library.

Plans were made for a membership campaign to bring more engineering

school librarians into active participation in the work of our Committee.

RUTH MCG. LANE, *Chairman*
NATALIE NICHOLSON, *Secretary*

English.—Two sessions of the English Section were held at the Annual Meeting in Cincinnati. At a dinner on Friday evening, June 23, the Section heard an address by Mr. Phillip W. Swain, Editor of *Power Magazine*, on the subject "English, the No. 1 Vocational Study for Engineers." Approaching the subject from the viewpoint of the user rather than that of the teacher of English, he discussed briefly the report of the Committee on Engineering Education After the War, and further emphasized the importance of knowing words. He recommended frequent drill for students in sentence revision and in writing letters to meet specific problems. His paper brought out a lively discussion on the meaning of the word "Humanities," the value of culture, the integration of subjects, and the place of report writing in the teaching of English. Twenty-one persons registered at the dinner session.

The second session was held Saturday, preceded by a luncheon at which forty-one persons registered. There were two talks, the first by Mr. Edward Hamilton, President of John Wylie & Sons, on the topic "Author! Author!" He discussed the problems connected with the preparation and publication of a book. The second talk was by Professor Walter Havighurst of Miami University on the subject "The Making of a Novel." He related a number of incidents from his own experience and gave very helpful suggestions for the study of the novel. The final item upon the program was a symposium on the subject "English Courses During the War and Afterwards." Prepared papers were presented by Professors C. W. Park of the University of Cincinnati, F. H. Gertz of Pratt Institute, Fred Abbuhl of Rensselaer Polytechnic Institute, E. C. McClintock of the University of Virginia, J. A. Ayers of the University of Louisville, and H. L. Creek of Purdue University. Professor Creek's paper was read, in his absence, by Professor W. O. Birk of the University of Colorado. Each man related briefly the experiences of the English Department of his college with the government units on his campus and drew some conclusions and observations on the value of the past year's work. Without separately attributing these ideas, for there was some duplication and overlapping, we may note the following suggestions that may have some bearing upon the work of all of us:

Praetice in student reading aloud is helpful and must be made permanent.
Reading as a basis for careful speaking and writing is neglected.
The concentrated plan of study has proved to be effective.
Report writing and other technical principles cannot be taught to freshmen.
Courses in English need to be given in each of the four college years.
The variety of student backgrounds in the same classrooms makes teaching difficult.
Adaptation of English to the engineer must be made.
Some found the attitudes of service men were not studious or conducive to excellence of work.
Some good points of army and navy programs should be continued.
Returning soldiers can be helped by courses in literature.
Recognition of special abilities among students must be increased.
Students *can* learn fast if they *must*.
The close relation between logical thinking and clear writing must be stressed.

There is danger in substituting courses in history, government, and geography for courses in English.

Definite standards in English for graduation must be maintained.

The business session which closed the meeting included several suggestions concerning postwar problems in English, but without any final action. A nominating committee was appointed who later brought in nominations of Professors Karl O. Thompson of Case School of Applied Science as Chairman, and J. E. Thornton of the University of Michigan as Secretary. Balloting by mail resulted in their election. The sessions were presided over by Professor Homer H. Nugent of Rensselaer Polytechnic Institute.

KARL O. THOMPSON
Secretary

Evening Engineering Education. —I give a brief resumé of the discussion which took place on the different topics.

1. Relation of E.S.M.W.T. Program to the Postwar Evening Program. Discussion led by H. P. Dutton, Illinois Institute of Technology.

There were varied opinions regarding this subject. Most of the discussion referred to the relation of the E.S.M.W.T. program to present evening school programs. At some institutions, the E.S.M.W.T. program seemed to be growing; at others, slacking off considerably. There was a general conclusion that the program had helped evening colleges generally, because of the contacts made with industry and close cooperation built up thereby which should be useful in the post-war period. With relation to the subject of discussion itself, it was generally agreed that the E.S.M.W.T. program would probably not continue in the postwar period, but that students who had studied in E.S.M.W.T. classes would be interested in enrolling in regular evening college classes; that, in general, E.S.M.W.T. programs would prove to have been very helpful to the growth of evening colleges.

2. Evening Engineering Undergraduate Work After the War. Discussion led by H. R. Beatty, Pratt Institute.

Discussion after Mr. Beatty's paper was read was quite general and no specific conclusions seemed to be reached. It was felt that it would be wise to introduce more of the "humanistic social stem" courses into the curriculum; also that cooperation with industry should be continually developed, in order to plan courses which would make the students eligible for promotion as soon as possible.

3. Evening Engineering Graduate Work After the War. Discussion led by H. E. Dyche, University of Pittsburgh.

Professor Dyche explained the University of Pittsburgh-Westinghouse graduate program under way in their Graduate School. He explained in detail how the plan works; how lecturers from industry are called upon to teach some of the courses and also how the institution, itself, maintains control. Mr. Dyche's discussion was of much interest to all and many questions were asked which leads to the belief that many of those present were interested in proposing evening engineering graduate work after the war for their own institutions. However, very few have programs in this field at the present time.

ROBERT D. HYNES

Instructional Methods and Comprehensive Examinations.—President Harry Rogers of Brooklyn Polytechnic Institute presided at the opening conference on Thursday, jointly attended by those interested in instructional methods and comprehensive examinations. Professor Scott B. Lilly of Swarthmore College served as Secretary of this session. There were about twenty-five people present to hear Professor B. R. Teare, Jr. of Carnegie Institute of Technology present a most stimulating paper on "Teaching Methods in Engineering Analysis," and Professor F. T. Mavis of Pennsylvania State College a companion address on "Teaching Methods in Engineering Applications." The first paper was discussed by Mr. A. R. Stevenson, Jr. and the second by Dean L. E. Grinter. There was considerable informal discussion among the group after the prepared portion of the program had been presented.

Professor Richard H. Frazier of M. I. T. presided at a luncheon conference on Friday, June 23, at which Professor LeVan Griffis of Illinois Institute of Technology presented a discussion of problems encountered in technical test construction for the Armed Forces Institute. Professor Griffis illustrated his paper with a number of lantern slides showing specific problems utilized by the Armed Forces Institute. There were about forty in attendance for the luncheon, but more than half of these had to leave before the speaker had finished because of the General Session scheduled at the University of Cincinnati at 2 p.m.

Professor Frazier announced at this meeting that the Council of S.P.E.E. had authorized a Division of Educational Methods to comprise the former Committees on Comprehensive Examinations and Instructional Methods. He appointed a nominating committee comprising Carl L. Svensen, Member-Secretary of the Texas State Board of Registration for Professional Engineers, as Chairman; George F. Bateman, Dean of the Schools of Engineering, Cooper Union; and William C. White, Dean of the College of Engineering at Northeastern University. The Committee was instructed to bring in nominations for Chairman, Vice Chairman, and Secretary of the New Division of Educational Methods at the dinner meeting on Friday evening.

Dean White presided at the dinner conference on Friday evening which was also joint with the Committee on Industrial Engineering. There were about twenty-five people present to hear an illustrated talk by Professor Mario C. Giannini, Consultant to the Visual Aids Division of the U. S. Office of Education, on the "United States Office of Education Program of Engineering Films." Professor Giannini ably described the plan under which this program is being operated and then showed several films that had recently been developed to give engineering instruction that would be immediately useful in the war effort.

Mr. Svensen reported for the Nominating Committee the following slate of officers for the year 1944–1945 for the new Division of Educational Methods: Chairman, Richard H. Frazier of M. I. T.; Vice Chairman, W. R. Bryans, New York University; Secretary, G. S. Timoshenko, University of Connecticut. It was moved and seconded that nominations be closed and that the secretary cast one ballot for the nominees as recommended by the Committee. This motion was unanimously

carried. Professor Frazier indicated that he would appoint appropriate committees during the year for the preparation of by-laws and for getting the work of the new Division under way.

WILLIAM C. WHITE
Secretary

Mathematics.—Professor Fairman, chairman of the Mechanics Division, called to order the joint session with the Mathematics Division shortly after 2 p.m. The first paper by Professor Arthur Korn (Stevens Institute), which was read by the secretary, compared technical educational methods and content in the Germany of a few years back and in the United States. Then Professor J. N. Goodier (Cornell) described the methods of engineering education in England. The most important difference between the methods in Europe and here was stated to be that in Europe the emphasis is on selecting and training the superior students whereas here we used the "shot-gun" method. The prospective superior engineer is spotted in what corresponds to our high school level and his training by the time he reaches the college level is superior to that found in the United States, especially in mathematics where these excellent students have already had an introduction to calculus. Moreover, the emphasis is on stiff comprehensive examinations for entrance and for completion of the required engineering knowledge instead of a required number of credits.

The ensuing discussion brought further comparisons. Professor R. F. Leggett (Toronto) told of his own educational experiences in England and of the prevalent methods employed in Canada. In Canada the lecture system is used, the classes are large and the colleges do admit all students who have graduated from accredited secondary schools, but with certain additional requirements which include thorough secondary training in algebra, trigonometry, and at least an introduction to analytic geometry. Professor Eriksen (Michigan) spoke briefly of his own training in Denmark.

The distinction was made between technical institutes and universities—England, for example, has 140 technical institutes and only 14 universities which grant engineering degrees. Professor Gilkey (Iowa State) pointed out that our education is based, in part at least, on the demands of industry and the use made of our graduates. The question was raised as to how the technical institutes in England are prevented from having "growing pains."

At the dinner meeting on Friday night Professor Stratton (Kansas State) presided as acting-chairman and presented a paper on *Testing and High School Preparation*. He told of the cooperative test developed through the cooperation of the colleges in Kansas to measure the high school product in mathematics and the effect of the test results back in the high schools. He emphasized the need for college teachers of mathematics to work energetically with high school teachers to improve the high school product, and the necessity of doing a better job ourselves in teaching the fundamentals of mathematics.

Professor C. G. Mumford (N. C. State) spoke about the *A.S.T. Program and Post-War Implications* and a paper with the same title by Professors H. P. Evans and C. C. MacDuffie (Wisconsin) was read by the secretary. The discussion that followed brought out many ideas and points of

view, of which the more interesting are as follows:

1. The A.S.T.P. forced "regimentation" of teaching and thereby assured all students of at least above average instruction—no one teacher could lag behind the others and, where the better teachers directed the work, definite improvement in over-all instruction was noted;

2. Newer methods of testing were suggested, though these tests need further development to ensure validity;

3. The content of each of the mathematics courses normally given to engineering students needs to be carefully scrutinized for its over-all relation to an engineering education (while the A.S.T. curricula were hurried, many of the students were found quite competent in subsequent courses);

4. Classroom use of graphical and numerical methods in teaching the fundamentals of calculus was found practicable in emergency programs and is suggested for continued use;

5. The classification of students according to ability into separate classes had many beneficial advantages (allowed superior students full development, and instructional methods in classes with below average students were drastically changed with emphasis on study habits and a review of basic material);

6. Motivation in emergency programs was in many cases so pronounced that students accomplished what seemed in advance to be impossible. (Parallel teaching of mathematics and applications in simultaneous E.S.W.M.T. courses in pre-radar are outstanding illustrations.)

After the discussion period a short business meeting was held. Professor H. K. Justice (Cincinnati) was elected chairman for the next year and Professor Ralph E. Root (Postgraduate School of U. S. Naval Academy) was elected to the Executive Committee for a three-year period.

JOHN W. CELL
Secretary

Mechanical Engineering.—The first conference was held on Thursday, June 22, at 2:00 p.m., and was arranged by the Manufacturing Processes Committee. The meeting was addressed by Mr. Roland Jenkins, Sperry Gyroscope Company, on the subject "Inspection Practices and Procedures in Their Relation to Mechanical Engineering," and by Mr. Walter Tangeman, Cincinnati Milling Machine Company, on the subject "Disposal of Surplus Manufacturing Equipment From the Machine Tool Builders Viewpoint." Prof. G. B. Carson acted as chairman of the meeting and Prof. S. J. Tracy served as secretary.

The Machine Design Committee of the Division arranged the 8:00 p.m. conference on Thursday, June 22, which was addressed by Prof. C. H. Young, Cooper Union, on the subject "Teaching Engineering Judgment in Machine Design," and by Prof. P. H. Black, Cornell University, on the subject "Machine Design Instruction in the Postwar Period." Prof. Egry, Notre Dame, showed a motion picture on Mechanisms. Prof. D. G. Ryan served as chairman and Prof. C. T. Grace acted as secretary.

On Friday morning a business meeting of the Division was held and officers elected for the year 1944–45.

A luncheon meeting on Friday, June 23, was addressed by Mr. N. P. Bailey, Research Laboratory, General Electric Company, on the subject "Today's Technical Advances Prepare To-

morrow's Engineers." Prof. F. L. Schwartz acted as chairman.

The dinner meeting at 6:30 on Friday, June 23, with Prof. B. H. Jennings as chairman, was addressed by Mr. A. R. Stevenson, Assistant to Vice President, General Electric Company. The subject was "Education of an Engineer."

A combined conference of all Division groups was held at 2:00 p.m. Saturday, June 24. Mr. Colin Carmichael, Associate Editor of *Machine Design*, presented the results of his survey on "The Future of Mechanical Engineering Education," and Prof. D. L. Arm, Iowa State College, spoke on "Accelerated Programs of Training in Mechanical Engineering." Prof. P. E. Kyle acted as chairman and Prof. R. R. Slaymaker served as secretary.

The following officers were elected for the year 1944–45:

Executive Committee:
- P. E. Kyle, *Chairman*, Massachusetts Institute of Technology.
- G. B. Carson, *Secretary*, Case School of Applied Science.
- Colin Carmichael, *Editor*, Associate Editor of *Machine Design*, Penton Publ. Co.
- F. L. Schwartz, University of Michigan.
- B. E. Short, University of Texas.
- R. R. Slaymaker, Case School of Applied Science.
- S. J. Tracy, College of City of New York.

Heat Power Committee:
- F. L. Schwartz, *Chairman*, University of Michigan.
- C. O. Mackey, Cornell University.
- Emory Kemler, Purdue University.

Mechanical Laboratory Committee:
- B. E. Short, *Chairman*, University of Texas.
- D. A. Fisher, Tufts College.
- J. F. Bailey, Northwestern.

Machine Design Committee:
- R. R. Slaymaker, *Chairman*, Case School of Applied Science.
- C. H. Young, Cooper Union.
- W. G. McIntosh, University of Toronto.

Manufacturing Process Committee:
- S. J. Tracy, *Chairman*, College of City of New York.
- F. S. Bauer, University of Colorado.
- W. W. Gilbert, University of Michigan.

PETER E. KYLE
Chairman

Mechanics.—The report of the joint conference with the Mathematics Division will be included in the report of the Mathematics Division. About sixty members attended our evening conference on June 22. This conference started with a short business session in which Professor R. V. James, University of Oklahoma, and Professor C. W. Muhlenbruch, Carnegie Institute of Technology, were elected to the Executive Committee of the Division to serve until 1948.

Three papers were presented at this conference:

1. Mechanics In Everyday Experience by R. J. Roark, University of Wisconsin, which was read by Professor M. O. Withey.
2. On the Derivation of Certain Formulas by Professor Neil Little, Purdue University.
3. A Placement Test for Mechanics by W. E. Wilson, Armour Research Foundation.

These papers were well received and were followed by a lively discussion.

At the luncheon meeting on June 23 which was attended by about fifty

members, Mr. R. E. Orton, Acme Steel Company, Chicago, presented a paper on "Education for Post War Industry." This paper was very important and should be given very serious consideration by Mechanics teachers.

The Executive Committee met and formulated tentative plans for the 1945 meeting. Those attending the meeting were Boomsliter, Draffin, Fairman, Withey, Harris, Wilson, and James. Fairman was elected chairman for one more year after which a new chairman will be elected.

The Council appropriated $100.00 for the continuance of the study of Achievement Test in Mechanics.

Seibert Fairman, *Chairman,* Purdue University,
J. O. Draffin (1945), University of Illinois.
F. L. Everett (1945), University of Michigan.
M. O. Withey (1946), University of Wisconsin.
C. O. Harris (1947), Illinois Institute of Technology.
W. E. Wilson (1947), Armour Research Foundation.
R. V. James (1948), University of Oklahoma.
C. W. Muhlenbruch (1948), Carnegie Institute of Technology.

SEIBERT FAIRMAN
Chairman

Mineral Technology.—Chairman Nold called the meeting to order and appointed a nominating committee of the following:

M. E. Coolbaugh, *Chairman,*
A. F. Greaves-Walker,
Curtis L. Wilson.

Chairman Nold then spoke briefly on post-war education. He outlined some of the problems the mineral industry schools would have to face.

E. G. Bailey, Vice-President, Babcock and Wilcox Company, spoke on "The Future of Engineering Education." Coolbaugh, Stephenson, Plank, Barker and Wilson discussed this very interesting paper.

Wm. Chedsey led a discussion on post-war education. He outlined the courses which he considered necessary to round out an engineer's education, viz., Economics, Psychology, Sociology, etc. J. R. Cudworth continued the discussion stressing the freshman year as the most critical and the need for inspiring teachers in that year. He also considered the needs of returning soldiers. H. E. Nold discussed means of tying the suggested courses together. M. F. Coolbaugh believed the war had given educators an opportunity to do a better job of training.

W. B. Plank read a paper entitled "Probable Enrollment in Mining, Metallurgical and Ceramic Engineering After the War." He reviewed past and present enrollment and predicted increases after the war. Chedsey and Hunt discussed the paper.

E. A. Stephenson read a paper by H. H. Power entitled "Petroleum Engineering Education and the Quantitative Approach." The paper outlined development of petroleum industry literature and discussed problems involved in recovering and processing petroleum which students should study. Discussion by Hunter.

M. F. Coolbaugh discussed "The Relation of Mineral Engineering to S.P.E.E." He said "Mineral Technology Division" should be changed to "Mineral Engineering Division," to conform with other divisions. He felt strongly that the mineral group needed more cohesion. Discussion by all present.

Plank moved that the new chairman

appoint a committee to study the possibility and desirability of changing the name of the Mineral Technology Division and report at the next meeting. This motion was seconded by Chedsey. Carried.

The Nominating Committee presented the following who were duly elected:

Chairman—W. B. Plank, Lafayette College.

Vice-Chairman—G. J. Barker, University of Wisconsin.

Secretary—J. R. Cudworth, University of Alabama.

A. F. GREAVES-WALKER
Secretary

Physics.—Conferences were held for the third consecutive year in conjunction with the American Association of Physics Teachers. The program was the following:

Thursday Morning, June 22, C. E. Bennett, University of Maine, *Chairman.*

We Taught Engineering Physics in the A.S.T. and Navy V-12 Programs—Or Did We? J. W. Woodrow, Iowa State College.

A.S.T.P. Experiences. W. W. Colvert, Illinois Institute of Technology.

Physics in the V-12 Program. R. L. Anthony, University of Notre Dame.

Discussion of Postwar Problems Brought into Focus by the A.S.T. and V-12 Programs in Physics. Led by Physics Staff, University of Cincinnati.

Thursday Afternoon, June 22, J. W. Woodrow, Iowa State College, *Chairman.*

Accrediting and Supplementing A.S.T. Courses. I. Walerstein, Purdue University.

Physics Instruction for Army Specialized Training Reserves. Lt. Col. D. F. Miner, A.S.T.D.

Rearrangements of Topics in Elementary Physics Courses. T. H. Osgood, Michigan State College.

The Physics War Front in Washington. H. L. Dodge, Office of Scientific Personnel, National Research Council. Contributed Papers (10 minutes):

The Use of Electrical Units in Elementary Physics. J. H. Howey, Georgia School of Technology.

How Not to Teach the Meaning of Mass. W. H. Michener, Carnegie Institute of Technology.

Friday Evening, June 23, Joint dinner with Electrical Engineering Division.

Saturday Afternoon, June 24, Joint Conference with Electrical Engineering Division: Ultra-High Frequenquencies and Electronics, J. G. Potter, Bell Telephone Research Laboratories, *Chairman.*

The Coordination of the Work of the Physics, Mathematics, and Electrical Engineering Staffs in the Formulation of Communications and Electronics Curricula, Including Ultra-High Frequency Techniques. E. A. Guillemin, Massachusetts Institute of Technology.

Educational Requirements for a Production Engineer. J. A. Hutcheson, Westinghouse Research Laboratories.

Discussion: A. B. Bronwell, Northwestern University.

The Thursday morning conference devoted to a discussion and evaluation of experiences and observations in the teaching of physics in the Army and Navy College Training Programs was entered into enthusiastically by the large group of physicists and engineers in attendance. In sharing experiences it was found that the problems en-

countered and the impressions obtained by all the departments participating in the programs were similar. The expedients adopted by the various departments in coping with the problems manifested an interesting diversity. The differences in fundamental objectives in physics instruction for technical students revealed in the points of view presented by various participants in the discussion were a challenge to every teacher to revise his own set of objectives. All were in agreement that many students manifested highly gratifying achievements in the programs, but there was a division of opinion on the desirability of endeavoring to teach physics regularly to college students before they had completed first year college mathematics.

The conference of Thursday afternoon continued the discussion of the morning and brought into focus the present situation and plans for post war physics instruction. The session afforded those concerned with the Army Specialized Training Reserves Program the opportunity to obtain specific information from several members of the A.S.T.D. staff in attendance. Discussion included the need for refresher courses for those with A.S.T. backgrounds returning to the colleges after the war, the desirability of devoting an increased portion of time in engineering curricula to physics instruction, and the demand for engineers with a background of undergraduate specialization in physics.

Following the joint dinner Friday evening most of the physicists remained to uphold physics in the lively conference reported by the Electrical Engineering Division. The contact with the electrical engineers was continued in the joint conference Saturday afternoon when cognizance was taken of the new advances in electronics and ultra-high frequency techniques while talking about the education of electrical engineers and applied physicists of the future. The discussion ranged from ideal curricula for those especially talented to curricula affording the minimum preparation for servicing the new types of equipment.

In response to a petition presented by physicists of S.P.E.E. through the Committee on Physics, The Council of the Society on the evening of Thursday, June 22, granted permission for the formation of a Division of Physics in the Society. A special short meeting was called by the Chairman of the Committee on Physics Friday evening, following the dinner with the Electrical Engineering Division, to organize a Division of Physics. It was voted that the officers of the division should consist of a Chairman, Secretary, and Executive Committee, the latter to be composed of members elected by the Division or nominated by the Chairman.

Following nominations from the floor the following officers were elected for the ensuing year:

Chairman, J. G. Potter.
Secretary, C. E. Bennett.
Executive Committee, J. W. Woodrow and J. H. Howey.

On subsequent nomination by the chairman H. L. Dodge was also made a member of the executive committee.

JAMES G. POTTER
Chairman

Relations with Industry.—Fifty people attended all or the major portion of this meeting. About one-half were from engineering schools and one-half from industry. There was considerable interest in the discussion and in spite of the uncooled room the meeting

continued until 10:40 p.m. There was a unanimous request that the work of this Committee be continued. The meeting was conducted on a conference basis following Mr. Fletcher's report.

Mr. Fletcher read several letters from Committee members. It was evident that all members feel it most desirable to develop a better mutual understanding between members of college and university faculties and industry.

Dean Potter, Purdue University, described the beginning of the E.S.M.W.T. courses and reasons for these. He cited the following round numbers of enrollments:

1940–41—106,000
1941–42—350,000
1942–43—480,000
1943–44—500,000 ?

He commented that most benefit really came to the colleges.

The President of the Indiana Manufacturing Association appointed a committee to see what Purdue can do to continue work similar to the E.S.M.W.T. He mentioned that engineering could learn something from agricultural educational activities. He suggested courses in such subjects as economics, sociology, biology, etc. for college credit, perhaps to be taken in industrial centers and inferred better understanding would be a product from such activities.

Mr. Mead, General Motors Corporation, cited two typical examples where industry cooperated with engineering educational institutions to the advantage of all parties:

a. Where Rutgers University conducted instruction for seven groups of women technicians for five plants of General Motors in the East. There were over 300 women in these seven groups.
b. Where Wayne University taught groups of women in drafting, the course having been specially designed by the General Motors Institute.

Mr. Mead reported both proved most satisfactory and this cooperation was an illustration of relationships between industry and engineering schools.

G. Edward Pendray, Westinghouse Electric and Manufacturing Co., described work of education in Westinghouse and their cooperation with the engineering schools. He described the national organization of high school science clubs, the development of aptitude tests in cooperation with the engineering educational people, their work with the science teachers on a nation-wide basis. They encourage people to attend night schools. All of these activities promote public relations.

Dean Potter suggested that good will is achieved by industries giving high schools and colleges surplus equipment.

Stromberg-Carlson, Rochester, New York, reported the following cooperative work as beneficial to all parties:

a. Cooperative research.
b. Employment of instructors on leave sometimes during summer but preferably for a year. He emphasized the added value of such cooperation in the smaller industries.
c. Suggested the possible extension of thesis development in the industries.

Mr. Hess, Renssellaer Polytechnic Institute, commented on using post-war planning committees and research as means to bring the engineering faculty and industrial groups closer together. He listed also courses for five or six important industries of about four weeks in length.

Mr. Fletcher, Caterpillar Tractor Co., raised the question whether the engineering schools would desire and could use to advantage brief reports on their graduates showing experience in their early employment. He also raised the question of visits for short periods of time—a week or so— and the policy of sending industrial men to school.

Dean Wilkinson, University of Louisville, commented that they would welcome reports on students as suggested by Mr. Fletcher and referred to faculty members becoming stale. He commented on members spending one to two weeks in industry and the problems of studying specialized fields such as paint, synthetic rubber. He also called attention to the value of such cooperation to members of faculties other than engineering.

Dean Freund, University of Detroit, raised the question whether exploration might show that trade associations might have contributions to make in closer team work. Dean Barlow, A. & M. College of Texas, described the work of the Aeronautics Committee of the S.P.E.E. in curricula development. Mr. Madsen, Westinghouse Electric and Manufacturing Co., commented on the value of cooperation in determining what to teach. He suggested subcommittees in various industries. Mr. Levins, University of Southern California spoke of the Consolidated Aircraft Curricula contributions and referred to a five point program including scholarships, fellowships for graduate study, faculty employment, etc.

ROBERT SPAHR,
Secretary

Professional Requirements and Growth of the Teaching Staff in Chemical Engineering*

By CHARLES F. BONILLA

Acting Head, Dept. of Chemical Engineering, The Johns Hopkins University

A questionnaire was mailed on September 13, 1943, to every chemical engineering faculty in the United States listed in the 1943 Directory of the American Institute of Chemical Engineers, pp. 10 and 11. On October 11 it was mailed to 20 additional schools teaching chemical engineering, whose names were provided by the U. S. Office of Education from the list of schools that have offered E.S.M.W.T. courses, which probably covers most of the engineering schools in this country. The schools have been separated into three groups, as follows:

Group A—Schools having a curriculum in chemical engineering which is approved by the Engineers' Council for Professional Development (as listed in the 1943 Directory of the A.I.Ch.E. Total = 48).

Group B—Schools having a Student Chapter of the A.I.Ch.E. (as listed in the 1943 Directory) but not having an approved curriculum in chemical engineering. (Total = 33.)

Group C—Schools having neither an approved chemical engineering curriculum nor a Student Chapter. (Total = 20, since increased to at least 21.)

Seventy per cent of the schools gave most of the information desired, and in the majority of cases the questionnaires were very carefully filled out.

*Prepared for a special survey of chemical engineering education by the American Institute of Chemical Engineers.

Growth of the Teaching Staff

Table I indicates that the faculty has grown approximately 60 per cent in numbers in the last eight years, while the number of schools offering a curriculum in chemical engineering has increased some 25 per cent. As might be expected, the schools now in Group A have increased least in number and in faculty size over this interval, and Group C the most. The estimated total faculty of 660, which would include some 24 who are on leave, exceeds the figure of 576 "actual" staff members as of November, 1942, reported by the National Roster (*Proc. S.P.E.E.*, **50**, 662, 1942).

Table II indicates that each faculty rank has grown roughly in the same ratio, with the possible exception of the graduate assistant, or junior instructor. It is also seen that each of the six principal ranks constitutes about one sixth of the total faculty, except that associate professors are somewhat under this and professors exceed it.

Analysis According to Teaching Rank

According to Table III it is seen that in going from Group A to C the "center of gravity" of the faculty moves to-

TABLE I

GROWTH OF THE TEACHING STAFF IN CHEMICAL ENGINEERING

School Group	Schools in Group (Jan. 1943)	Schools Reporting	Total Faculty Members Reported. Members on Leave (in parentheses) are included			Schools Reporting No Faculty on 7/1/1935	Ratio of Schools Having Faculties 1943/1935	Estimated Total Teaching Staff 7/1/1941
			As of 7/1/1935	As of 7/1/1943	Ratio 1943/1935			
A	48	39	239	358 (10)	1.50	4	1.11	440
B	33	19	50	93 (4)	1.86	3	1.19	161
C	20 (?)	13	16	38 (3)	2.37	7	2.17	59
All	101	71	305	489	1.60	14	1.25	660 (by groups)

wards a higher rank, probably because: (1) the accredited schools require more instructors and laboratory assistants for their larger student bodies, (2) the lower group schools tend to hold their faculty by granting higher ranks, and (3) the lower group schools do not offer graduate work nor have graduate assistants to as great an extent (in fact there were no graduate assistants in all thirteen Group C schools replying). Table III also shows that, with one exception, in every rank there is a decrease in faculty members per institution in going from Group A to B to C. The position of the higher group schools is also reflected in a higher "lowest permanent rank," and the encouragement of research to a lower average rank.

REQUIREMENTS FOR FACULTY APPOINTMENT

Requirements for appointment to the different ranks are not easy to average arithmetically. Except for a slight easing off in Group C they seem quite uniform. Out of the 71 schools reporting, a total of 58 stated their requirements. Of this number 47 require a Doctor's degree for appointment to some rank (most commonly

TABLE II

GROWTH AND DISTRIBUTION OF THE TEACHING STAFF BY FACULTY RANK

Faculty Rank	Number Reported (Including Those on Leave)				Estimated Total Teaching Staff, 1943 (Est. by Groups)	Percentage of Faculty in Each Grade, 1943		
	1935	1943	Ratio 1943/1935	Percentage of Total, 1943		Group A	Group B	Group C
Prof.	61	103	1.69	21.0%	139	20.5	22.6	21.0
Assoc. Prof.	32	54	1.69	11.0%	75	9.2	11.8	26.3
Asst. Prof.	48	76	1.58	15.5%	106	14.4	16.1	26.3
Instr.	54	91	1.69	18.6%	124	18.2	24.8	7.9
Grad. Asst.	64	89	1.39	18.2%	114	21.8	11.8	0
U. Grad. Asst.	46	72	1.56	14.7%	97	14.8	12.9	18.4
Lecturer	0	4	—	.8%	5	1.1	0	0

TABLE III

MISCELLANEOUS DATA CONCERNING FACULTY RANKS (1943)

School Group	"Center of Gravity" of Faculty	Lowest "Permanent Rank"	Lowest Rank Encouraged to Conduct Research	Lowest Rank Permitted Consulting Work	Average Faculty Members per Department						
					Prof.	Assoc. Prof.	Asst. Prof.	Instr.	Grad. Asst.	U. Grad. Asst.	Total
A	3.56	3.3	4.8	4.2	1.88	.85	1.32	1.67	2.00	1.36	9.18
B	3.30	3.7	4.3	3.8	1.11	.58	.79	1.21	.58	.63	4.90
C	2.95	4.0	4.1	3.9	.62	.77	.77	.23	0	.54	2.92
All	3.38	3.5	4.5	4.0	1.44	.76	1.08	1.29	1.25	1.01	6.89

Key: Professor = 1, Assoc. Prof. = 2, Asst. Prof. = 3, Instructor = 4, Grad. Asst. = 5, U. Grad. Asst. = 6

assistant professor and higher). A few schools specify "General Qualifications" without rigid minimum requirements. A few specify years of experience, usually 5 years minimum for assistant professor and 10 years for a higher rank. More schools specify teaching than industrial experience, but possibly this is not a preference, but merely the guide in promoting men from a lower teaching rank. Of the schools specifically stating that a certain number of years of teaching and/or industrial experience was required, in Group A six mentioned teaching and six industrial, in Group B five mentioned teaching and two industrial, and in Group C three mentioned teaching and none industrial. This may indicate, however, that industrial experience, much sought after in selecting faculties for the higher group schools, is not as necessary in (or attainable by?) the lower group schools.

MEMBERSHIPS IN PROFESSIONAL SOCIETIES

The data on memberships in professional societies are not entirely reliable, since replies were clearly incomplete on this point. The names of the faculty members were not specifically asked for, nor generally provided, so it was not possible to check thoroughly. It is felt, however, that the percentages listed in Table IV are probably accurate enough for comparison purposes, except the figures for full professors in Group C, which are based on only 4 individuals.

It is apparent that interest in the A.I.Ch.E. and S.P.E.E. drops among full professors in going from Group A to C, partly due, probably, to broader duties and interests involved in the smaller faculties, particularly a greater concern in chemistry (as evidenced by the parallel increase in memberships in the A.C.S.). The apparently discrepant increase in A.I.Ch.E. membership and active membership therein going from Groups A to C among faculty below full professor is primarily due to the parallel decrease in undergraduate and graduate assistants.

Dugald C. Jackson's monograph, "Present Status and Trends of Engineering Education in the United States" (E.C.P.D.), contains a wealth of statistical information on engineering faculties. The only subject which is broken down into the separate en-

TABLE IV

MEMBERSHIPS IN PROFESSIONAL SOCIETIES—1943
(APPROXIMATE)

School Group	Faculty Rank	Member A.I.Ch.E.	Active Member A.I.Ch.E.	Member A.C.S.	Member S.P.E.E.	Other Societies per Cap.	Total Societies per Cap.
A	Full Professors	80%	63%	56%	27%	.65	2.28
A	Below Full Prof.	24%	3%	22%	5%	.20	.71
B	Full Professors	65%	41%	65%	12%	.41	1.82
B	Below Full Prof.	33%	6%	28%	7%	.13	.82
C	Full Professors	50% ±	25% ±	75% ±	0% ±	1.5	3.00
C	Below Full Prof.	46%	13%	21%	4%	.29	1.00
All	Full Professors	76%	57%	59%	23%	.64	2.22
All	Below Full Prof.	27%	4%	23%	5%	.20	.75
All	Full Professors (1935 ±)	57%	53%		46%		

gineering fields, however, is that of full professor society memberships and listings in Who's Who, etc. His figures indicate 53 per cent of the professors in chemical engineering are active members of the A.I.Ch.E., and 57 per cent are in any grade, also that 46 per cent are members of the S.P.E.E. The last row in Table IV indicates that the percentage of professors who are members of the A.I.Ch.E. has increased notably. Considering that the number of professors has increased by about 69 per cent between 1935 and 1943 (Table II), the professorial membership of the A.I.Ch.E. has more than doubled. Comparison with the S.P.E.E. membership list indicates the figures in Table IV are too low, since many must have neglected to list their S.P.E.E. membership in the questionnaire. Approximately 24 per cent of all chemical engineering teachers are members, and 47 per cent of all full professors. The last figure evidently hasn't changed since Jackson's report.

The figures for A.I.Ch.E. membership tabulated have been corroborated by a direct count of teachers listed in the 1943 Directory of Members. The count gave 226 as of January 10, whereas data in Tables II and IV yield 246 as of July 1, a reasonable check. About eighty professors were members in January 1943, only 58 per cent of the estimated number of professors in July 1943. The discrepancy between this figure and the 76 per cent listed in Table IV is probably due to some new applications, and to the greater likelihood that members of the A.I.Ch.E. would answer the questionnaire than would non-members, thus throwing out of line the proportionality between members and professors. From the 1943 Directory and Table II it is figured that about 49 per cent of the associate professors, 52 per cent of the assistant professors, 32 per cent of the instructors, and 12 per cent of the graduate assistants are members of the A.I.Ch.E.

PROFESSIONAL EXPERIENCE

Table V contains the average years of teaching experience in the present rank, and the present school, and total years of teaching, averaged for each faculty rank except undergraduate assistant and for each school group. Averages for a given rank in all groups, a given group in all ranks, and a grand

average are also listed. It might be mentioned that some of those filling out the questionnaires listed about one more year at the present school, than total teaching. The former may have included a year of research, or several of part time teaching.

The same figures are given for industrial experience, broken down to production, development, research, sales, and administration. Whenever full time non-industrial research was reported it was placed under industrial research. However, this classification apparently does not contain any appreciable amount of part time research carried on by faculty members, that being contained in the years of teaching experience. Some faculty members reported years of teaching and also years during which part time consulting work was engaged in along one

TABLE V

AVERAGE YEARS OF PROFESSIONAL EXPERIENCE, CONVERTED TO FULL TIME BASIS

Rank	Professors				Associate Professors				Assistant Professors			
Group	A	B	C	All	A	B	C	All	A	B	C	All
Present Rank	9.0	7.2	13.1	9.0	3.1	2.8	3.5	3.1	3.4	3.1	2.2	3.2
Present School	15.5	14.2	17.4	15.4	9.0	5.3	5.4	7.6	5.9	6.4	4.9	5.9
Total Teaching	18.4	15.2	22.5	18.2	9.9	8.0	9.3	9.4	6.6	7.6	6.2	6.7
Teaching, when Appointed to Present Rank	9.4	8.0	9.4	9.2	6.8	5.2	5.8	6.3	3.2	4.5	4.0	3.5
Production	1.3	1.7	1.2	1.3	1.1	2.1	.6	1.2	.7	.8	.4	.7
Development	1.8	3.1	.4	1.9	1.3	.8	1.4	1.2	1.0	.9	3.5	1.4
Research	2.1	3.7	.4	2.3	2.4	2.1	1.4	2.1	1.1	1.2	.9	1.1
Sales	.1	.1	0	.1	0	.1	.1	0	0	0	0	0
Administration	1.4	1.4	.7	1.3	0	.5	.9	.3	.5	.2	.1	.4
Total Industrial	6.7	10.0	2.7	6.9	4.8	5.6	4.4	4.8	3.3	3.1	4.9	3.6
Ratio Teaching to Industrial	2.7	1.5	8.3	2.6	2.1	1.4	2.1	2.0	2.0	2.5	1.3	1.9
Teachers Covered	72.5	18.0	8.0	98.5	33.0	10.0	10.0	53.0	51.5	12.0	10.0	73.5

Rank	Instructors				Graduate Assistants				All Ranks from Prof. to Grad. Asst.			
Group	A	B	C	All	A	B	C	All	A	B	C	All
Present Rank	2.1	2.2	1.0	2.1	1.0	.3	—	1.0	4.6	3.8	5.3	4.5
Present School	2.4	3.1	1.3	2.6	1.2	.8	—	1.1	8.1	7.1	7.9	7.9
Total Teaching	2.6	3.7	1.0	2.8	1.0	.3	—	.9	9.4	8.2	10.9	9.3
Teaching, when Appointed to Present Rank	.5	1.5	0	.7	0	0	—	0	—	—	—	—
Production	.8	.8	.3	.8	.2	0	—	.2	.9	1.3	.6	1.0
Development	.7	.5	.3	.7	.3	0	—	.3	1.2	1.3	1.7	1.2
Research	.7	.7	.3	.7	.3	0	—	.3	1.3	1.9	.8	1.4
Sales	0	.1	0	0	0	0	—	0	0	0	0	0
Administration	.4	.3	0	.4	0	0	—	0	.7	.6	.5	.6
Total Industrial	2.6	2.4	.9	2.6	.8	0	—	.8	4.1	5.1	3.7	4.2
Ratio Teaching to Industrial	1.0	1.5	1.1	1.1	1.3	—	—	1.1	2.3	1.6	2.9	2.2
Teachers Covered	54.3	22.0	3.0	79.3	19.0	2.0	0	21.0	230.3	64.0	31.0	325.3

or more of the industrial lines mentioned. In such cases the years part time in each line were arbitrarily divided by five and considered as full time years, without decreasing the number of teaching years. Thus, the average total years of professional experience in Table V are slightly higher than the actual calendar years. The discrepancy is probably no greater than about 2 per cent, and could be no doubt ascribed to a longer work week than usual.

It is seen that the average full professor has taught for 18.2 years, all but 2.8 years of it at his present institution. He has held his present rank for 9 years, thus he had 9.2 years of teaching experience when appointed full professor in 1934. He has also accumulated 6.9 years of industrial experience, probably most of this before reaching the rank of professor, so a total of some 15 to 16 years of teaching plus industrial experience were offered by him when he was appointed professor. The associate professor averaged 6.3 years of teaching and possibly 4 years of industrial experience when appointed to this rank in 1940. The average assistant professor was also appointed in 1940 and had 3.5 years of teaching experience and about 3 of industrial. The average instructor was appointed in 1941, and had had less than a year of teaching, and 2½ of industrial experience. These figures may be useful as criteria for appointments and promotions.

An interesting conclusion from Table V is that the faculty in Group B schools averages one more year of industrial experience and one less of teaching than Group A faculties. This is mainly located in the rank of professors, and to a lesser extent in that of

TABLE VI

AVERAGE HOURS PER WEEK TEACHING LOAD

Rank	Professors				Associate Professors				Assistant Professors			
Group	A	B	C	All	A	B	C	All	A	B	C	All
Lectures	4.8	5.0	6.6	4.9	7.8	6.3	6.2	7.2	5.1	4.3	7.2	5.3
Recitations	2.7	.9	1.9	2.3	2.3	1.8	2.5	2.2	2.5	3.2	2.7	2.6
Laboratories	4.6	3.7	5.7	4.5	7.3	5.0	5.3	6.4	8.1	7.4	7.8	7.9
Research	7.2	9.9	3.1	7.4	6.6	6.4	3.6	6.0	7.1	2.8	2.4	5.8
Administration	7.8	9.8	3.7	7.9	3.3	5.0	2.5	3.5	—	—	—	—
Total	27.0	29.2	21.0	27.0	27.1	24.5	20.1	25.2	22.8	17.7	20.1	21.5
Teachers Covered	70.5	18.0	7.0	95.5	31.0	10.0	10.0	51.0	50.5	12.0	10.0	72.5

Rank	Instructors				Graduate Assistants				All Ranks from Prof. to Grad. Asst.			
Group	A	B	C	All	A	B	C	All	A	B	C	All
Lectures	3.8	4.3	0	3.8	.2	.3	—	.2	4.3	4.6	7.5	4.5
Recitations	2.8	1.4	4.0	2.4	2.0	0	—	1.9	2.5	1.6	3.0	2.3
Laboratories	9.7	11.0	9.0	10.0	8.1	13.0	—	8.5	7.3	7.5	7.9	7.3
Research	2.9	7.5	0	4.1	7.7	0	—	7.1	6.2	6.8	3.4	6.1
Administration	—	—	—	—	—	—	—	—	2.7	3.5	2.1	2.8
Total	19.0	24.2	13.0	20.4	18.0	13.3	—	17.7	23.0	23.9	19.8	22.9
Teachers Covered	52.3	22.0	2.0	76.3	37.0	3.0	0	40.0	241.3	65.0	29.0	335.3

associate professors. Full professors of the 3 groups have the same total professional experience, about 25 years, of which 27 per cent is industrial experience in Group A, 40 per cent in Group B, and 11 per cent in Group C. A considerable number of graduate assistants in Group A schools were not included in this compilation, due to the fact that no data were supplied on their experience, rather than arbitrarily assuming they had none.

Faculty Teaching Load

The average number of hours per week spent in lectures, recitations, laboratory supervision, required research, and administration are given in Table VI. It seems likely that some of the research hours reported are not required, although the intention was to record only work that is more or less required. Administration was intended to cover departmental administration only, but evidently grading of papers, etc., was included under this category at some schools, with all members of the faculty credited. Whenever this was noted, only the hours listed for the head of the department were counted, and these were reduced somewhat, proportionately to his hours of teaching.

It is seen that the total hours per week reported decrease gradually in general, in going to lower teaching ranks, from 27 to 18 hours per week. Teachers in Grade C schools average considerably fewer hours per week. The largest items in the average professor's schedule are administration and research, and in the associate professor's, lectures. Assistant professors and lower spend more time in laboratories than in the other activities, with instructors being particularly low in the item of research. Most of them would have finished their doctorate and be organizing their teaching activities, thus have little time for research. Another possibility is that men satisfactory at teaching but not gifted for research have been left in the rank of instructor, and are not expected to engage in research.

From the final grand average it may be computed that of all required faculty hours reported about 20 per cent are lectures, 10 per cent recitations, 31 per cent laboratories, 27 per cent are spent in research, and 12 per cent in departmental administration.

Degrees Held by Faculty Members

Table VII gives the percentages of the faculty members reported according to the highest degree they hold. In a number of returns the major field was not indicated. These cases were divided up between chemical engineering and "other fields" proportionally to the number of returns specifying each.

It was not attempted to compare these data with those of the Jackson report (for all engineering departments). This could be done by combining data from Table VII and Table II. For instance, it is calculated that 36.5 per cent of all faculty members in Group A schools hold Doctor's degrees, a considerably higher figure than the 13 per cent given by Jackson for his highest classification of engineering schools as a whole in about 1935.

Inbreeding of Faculty

Table VII also contains the percentages of faculty members whose degrees were taken entirely or partially at the institution in which they are teaching. It is evident that considerably less inbreeding is found in the

TABLE VII

DEGREES HELD BY FACULTY MEMBERS

Rank	Prof.		Assoc. Prof.		Asst. Prof.		Instr.		Grad. Asst.	
School Group	A	B+C	A	B+C	A	B+C	A	B+C	A	B
Doctor in Ch.E.	39%	42%	50%	42%	44%	32%	14%	8%	0%	0%
Doctor in Other Field	39	42	33	19	24	16	3	0	0	0
Master in Ch.E.	6	16	14	28	22	48	51	69	11	0
Master in Other Field	8	0	0	7	6	0	0	0	6	0
Bachelor in Ch.E.	5	0	3	0	2	2	32	23	83	100
Bachelor in Other Field	3	0	0	4	2	2	0	0	0	0
All degrees are from present school	14%	10%	13%	5%	35%	9%	38%	36%	44%	67%
Some degrees are from present school	17	3	23	5	13	18	23	8	0	0
No degrees are from present school	69	87	64	90	52	73	38	56	56	33
Total Individuals	70	29	31	21	46	22	52	25	18	3

group B and C schools, but this is probably largely due to the fact that chemical engineering departments in B and C schools have not been established as long, and fewer of them offer the higher degrees.

Some returns listed only the school at which the highest degree was obtained. These were arbitrarily placed in the categories of all degrees or none from the school in which now teaching, although undoubtedly some of them should fall into the middle group.

Combining these data with Table II, it is possible to obtain figures for the whole faculty and compare with Jackson. For instance, he gives that about 29 per cent of all engineering faculty members in the highest school group received all of the degrees from the school in which they are now teaching. This is very close to the figure of 30.4 per cent here obtainable for Group A schools. Thus chemical engineering is about in the same position as the other engineering fields in this respect.

STUDENT-FACULTY RATIO

Data on student enrollment were not requested in the questionnaire; however some data have recently become available. Assuming the schools not having student chapters of the A.I. Ch.E. average half as many students as those having them, the Committee on Student Chapters report for 1942-3 reports about 17,700 total undergraduates and 2,500 seniors in chemical engineering in this country checking the S.P.E.E. figures for October 1942 of 14,691 and 2,450, respectively, and the National Roster figures (loc. cit.) for November 1942 of 17,252 undergraduates and about 2,950 in their last year. A later survey for the fall of 1943 indicated about 10,900 total undergraduates including Army and Navy trainees, and 2,300 seniors. Assuming that some 4,000 "student-years" of chemical engineering courses were taken by these undergraduates, it is seen that the 1942 country-wise av-

erage was some 6.3 students per available faculty member. Considering that the average teacher spends 14.1 hours teaching per week including laboratories (Table VI) and assuming an average of 27 hours per student week of classes and laboratories, the average number of student-hours per faculty-hour, or the average size of the group corresponding to each teacher figures out to 12 students. Assuming 15 of the weekly student hours are lectures and recitations, the average class room group is 14 students per teacher and the average laboratory section contains 10 students per teacher. The total number of chemical engineering students enrolled per chemical engineering faculty member in 1942–3 was about 27, and in the fall of 1943 was 17. Jackson's figure was 18 for all engineering departments.

Engineering—a Profession *

By L. M. GRAM

Professor and Chairman, Dept. of Civil Engineering, and Director of Plant Extension, University of Michigan

In discussing this subject, after more than forty years in the practice and teaching of engineering, I am approaching the state of mind to which Palmer C. Ricketts, late Director of Rennselaer Polytechnic Institute, confessed when he was invited to write an article on Engineering Education. Said he, "I do not feel competent to do so; I have had only 54 years of experience in teaching and administrative work in engineering colleges, and feel that discussion of that subject should be left to those more experienced and perhaps more dogmatic."

President Little when at the University of Michigan liked to repeat the point of distinction between members of the faculty and the college president, namely that professors knew less and less about more and more while the president knew more and more about less and less.

The engineer has basked in the sunlight of brilliant achievement for so many years without acquiring much more than a deep tan of self-satisfaction that it might now be appropriate to suggest that he retire to the shade of public opinion and find out what others really think of him. Specifically, what are the qualifications for admission to the engineering profession, or, is it a profession in the generally accepted meaning of the term, and if so, how does it compare with others?

By derivation of the term, one who practices a profession is a self-starter; in other words, any one who proclaims unusual learning, or skill in any field whatsoever, acquires, *ipso facto*, a profession. By common usage of the term, practice of a profession implies service to others; therefore it has a social and economic significance, and in those fields where public safety or health is involved, society has a right and does provide protection against impostors or unqualified practitioners by the enactment of state registration laws.

There are many definitions of what an engineer may profess to be able to do. For example, this one grew out of a discussion of a group of engineers some years ago, and has some merit:

"Engineering is the judicious and ingenious application of the principles of science to the economic production and use of materials and energy."

Others might be quoted *ad infinitum*,* but all of them are so broad, and some of the principles of science like the law of gravity are so simple in application, it is not surprising that the engineering profession has an almost unlimited number of members. By comparison, the sole function of a physician or medicine man, as he is known in primitive social groups, is to cure human ills,

* Presented at the annual meeting of the Michigan Section, May 6, 1944.

* Marston, *Proc. A. S. C. E.*, p. 1736; 1929.

and the degree of success of his services is easily appraised. Incidentally, the nature of human ills has not changed since the beginning of man, although the skill of the physician has improved almost miraculously. Likewise the lawyer is charged with the responsibility of enforcing such rules and laws as are made by the community for its own general welfare; while the clergyman attends to the spiritual guidance of his flock. The urgent needs for these definite services have been ever-present, and the individuals who, either singly or in combination, performed them have been looked upon as though endowed by surpassing wisdom, hence the probable origin of the classification "learned" professions.

Differing from the physician, lawyer and clergyman, the engineer has little call for man-to-man service, and his presence in the social structure is comparatively recent. It made little practical difference to people in ancient days whether the globe was round or flat; whether there were electric lights, telephones, or rapid transit; but bodily and spiritual ills have been ever present. With the advancement of science, however, the engineer has stepped in as a liaison, so to speak, between science on the one hand and the production of devices for the necessity, comfort, convenience and luxury of the general public on the other. Incidentally, it is extremely difficult to distinguish between luxury and necessity, the one being transformed into the other as smoothly as fade-outs in the movie.

On a farm where I spent the happiest days of my life as a boy, one seldom travelled more than two or three miles from his abode except to exchange eggs for other food stuffs at the village store, or to attend church, where the exchange of gossip was made in the absence of the telephone. Today, insofar as transportation is concerned, there are enough motor vehicles in Michigan to transport simultaneously and with dispatch every man, woman and child in the state.

Whether the engineer is keeping the scientist busy by the demands of society or whether the scientist is keeping the engineer busy by passing one after another of his discoveries to the engineer I am unable to say. It has been an eminently satisfactory and productive coalition, however, as developments of the past clearly demonstrate. It is not an engineering question to decide whether we are any happier by reason of some of the many comforts and conveniences that the engineer has helped to produce. I can say without fear of contradiction, however, that, once having become accustomed to the modern standards of living, we would be decidedly unhappy without them. In any event, the engineer may well feel proud of his contribution to the modern tempo of civilization, but the doctors, lawyers and clergymen still make up the so-called "learned" professions.

What if anything do the engineers propose to do about it? I submit these suggestions for discussion, all of which are of interest to the members of this organization.

I. Greater respect for the engineering profession by its own members as well as by the public. This end can be accomplished in part at least by recasting the training of the engineer, and by popular presentation of his accomplishments. Indeed, no stories are more fascinating than those of the development of many details of our modern civilization, in which the engineers have played such an important part. Query: Is it not probable that young men having literary interests as well

as the personality, imagination and vision to become successful engineers are diverted into other fields by the apparent undiluted technicality of engineering training? In other words, to use a trite illustration, does it not appear that the engineer is so preoccupied by the trees that he overlooks the beauty and grandeur of the forest?

II. A clear definition of the qualifications for membership in the engineering profession, as determined by practitioners for the best interests of society.

The necessity of circumscribing the engineering profession has been brought emphatically into the foreground by present labor conditions, due to the fact that a large percentage of practicing engineers belong to the employee and not employer or independent practitioner groups. Personally I dislike to see the engineering profession, as I visualize it, forced into the category of so-called pressure groups. On the other hand, it seems absolutely necessary that some appropriate steps be taken for its own protection and for the preservation of the dignity of the profession. Criteria of professional status, such as graduation from an accredited engineering college, or membership in a national society, are inadequate to solve our current employment problems. We will agree, I think, that college graduates are not prepared to assume responsible charge of engineering projects until after a period of practical training or internship, if you please; or they may develop into most competent engineers, eligible for state registration and for the highest grade of membership in a national organization without ever having attended college. Neither of the criteria mentioned is recognized legally, however, and it is practically impossible to distinguish between the college graduates who are doing subprofessional work alongside hundreds of others in the employee group some of whom may rise to what might be defined as professional status while others continue indefinitely to follow what might more properly be called a trade. Membership in one of the national organizations may come nearer to defining professional status, and it is gratifying that one of them at least is giving serious consideration to this difficult situation.

III. Broadening of educational background.

I have already pointed out that in general a diploma in engineering *per se* does not qualify the graduate to undertake the degree of responsibility that should be implied by professional status. The college training, however, does carry the student through a critical period of mental maturity, and if properly broadened it should provide the foundation for the type of engineering professionalism that unfortunately in my humble opinion a small minority of colleges envisage. We may as well face the fact that engineering is not now looked upon by the general public as a so-called "learned profession." On the campus our students belong to the "engine" school, despite the earnest and persistent efforts of some administrators to discourage that concise but uncomplimentary designation. The engineer is respected for his ability to discuss slide rule and laboratory problems but not those involving public affairs, human relationships or æsthetics. From my own personal knowledge presidents of the University since Dr. Angell have advocated revamping the educational policy in engineering, which, of course, cannot be done individually.

From the standpoint of college training there would now be less support for our application for admission to the inner circle of so-called learned professions than years ago when the law degree was given by the University to any student of good moral character who had a district school or high school preparation for college, and who completed a two-year course in the Law School. Up to 1890 a student was required to attend medical school for only three years of nine months each in order to receive the degree of Doctor of Medicine, while as far back as 1853, when the curriculum in Civil Engineering was established at Michigan, the course required four years for the degree; and it is a matter of history that in 1895 objection was offered by leading members of the Engineering faculty to a complete separation from the Literary College because of the probable loss of broadening features of the curriculum. That their fears were well grounded is demonstrated by the fact that a large percentage of the liberalizing courses have since given way to an ever-increasing demand for more technical work. In this connection let me give you a bit of statistical data. Some years ago more than 5,000 members of one of our national engineering organizations expressed a combined opinion that attributes such as personality, character, initiative, resourcefulness and ability to get along with and handle men were of far greater importance to the success of an engineer than technical training. Also, a tabulation of data shows that seventy per cent of engineering graduates make vocational use of their technical skill for the first few years after graduation, but gradually drift into administrative work, until at the twenty-five year experience point seventy per cent are engaged in directing the work of others.

If I may speak frankly, the efforts of this Society toward broadening the engineering curriculum have not been very effective. About twenty years ago the Deans of fourteen midwestern engineering colleges met in conference to consider this problem, and agreed that the period of collegiate training should be adjusted so as to make possible the inclusion of liberalizing courses.* Preliminary steps in that direction were about to be taken when a thorough study of the problem of engineering training was made possible by this Society under the sponsorship of the Carnegie Foundation. After several years of hard work, and the compilation of volumes of valuable data, a report was issued which set the liberalizing of engineering education back on its heels for many years. In a few words the gist of it was that we were then doing a pretty good job, or at least, if our house were put in order, four years of residence was long enough. The fact remains that, if a four-year curriculum shall be further liberalized, technical courses must be displaced, and any one familiar with efforts to that end realizes how futile they are. In fact, as time goes on, the trend is all the stronger in the other direction.

Industry, hard pressed for more technically trained men than the colleges can supply, has doubtless solved its problem in part at least by the employment of men with less than four years of collegiate training. These men may consider themselves engineers by profession, and by basic definition and in the minds of the public they are

* Engineering Education, Vol. XXX, p. 170.

perfectly justified in doing so. But I submit that that situation is not elevating the standards of the engineering profession, and moreover I surmise that it is not easing the labors of those who are now trying to solve serious labor problems in which college graduates are directly concerned.

Therefore, may I repeat, it is the duty of the engineering profession to define its own standards, and then to spread the gospel to the public and to the lawmakers just as the doctors and lawyers have done long since.

IV. Greater participation in public problems.

There is implied in the public recognition of any profession an obligation to service to the community both as individuals and as a whole. The success of a democratic form of government is gauged by the extent to which its citizens participate in its management; and we will agree there is greater need now than ever before for every citizen to acquaint himself with public problems as they arise, and to exercise his right and duty to assist in solving them. The attainment of life, liberty and happiness, for which our forefathers declared one hundred and fifty years ago and for the preservation of which we are desperately struggling today, is in a large measure a challenge to the engineering profession, and I am sure that its record will reflect honor and credit. It is my hope however that our students in future years will have been more deeply impressed with the idea that the products of the engineering profession beget problems involving human relationships and that the engineering profession has a responsibility to think about one as well as the other.

I have tried in this rather sketchy address to make a few suggestions which might lead to an elevation of the standard of the engineering profession, for the betterment of society and incidentally that of engineers personally. Liberalizing of the educational background is the phase of the problem with which this Society should concern itself, and now. Perhaps I should add that any views expressed by me are my own and do not, even by implication, represent those of the Engineering College or of my own Department.

Finally I submit that there never was a better time for the engineering colleges as a group to design a new model that will enable engineers to keep pace with other professions in the post-war period. My experience however does not encourage me to expect that it will be done until demanded by the profession as later defined and understood by the public.

The Armed Forces Institute and the Problem of Credits Earned Under This and the A.S.T. Program*

By W. R. BRYANS

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The United States Armed Forces Institute was established in April, 1942, on the recommendation of the joint Army-Navy Committee on Welfare and Recreation, and it has since developed three principal functions. One of these is well-known to most of us, and also to the men in service, and consists of providing machinery by which the soldier or sailor can continue his education by means of correspondence courses. The Institute, through eighty coöperating colleges, furnishes correspondence courses in about 350 subjects on the college level and some 87 on the high school level. In addition, the Institute itself offers 64 courses by correspondence, most of these being of high school or vocational nature. In the case of Institute courses, there is no cost to the student except a two-dollar enrollment fee. Courses taken from coöperating colleges carry the extension course fees for texts and tuition, but the government pays one half of these, up to twenty dollars.

Wide publicity has been given to this phase of the Institute's program in all Army and Navy centers; and, as of February, 1944, more than 20,000 service men and women had enrolled in correspondence extension courses on the college level and more than 100,000 in the free Institute courses. The fields chosen by those enrolled in the standard university correspondence courses, and listed in the order of their popularity, are: 1. Social Studies; 2. Mathematics; 3. Business; 4. English; 5. Foreign Languages; 6. Science; 7. Mechanical Engineering; 8. Electrical Engineering; 9. Professional subjects; 10. Miscellaneous.

The second function of the Institute is that of assisting Army and Navy personnel to obtain academic credit for their in-service training and military experience by providing the machinery for collecting data on such training. These data are furnished to a college, designated by a service man, in the form of what is known as a "profile." This consists of a letter of transmittal and four or five pages describing the time and material content of the service course, basic training, or service job training, together with academic grades and grades on such qualities as leadership. To quote from the letter of transmittal:

> To assist service personnel secure academic credit for their in-service training and experience; and further, to assist educational institutions in evaluating in-service training and experience in terms of academic credit, the United States Armed Forces Institute has established a Central Clearing Agency for Ac-

*Presented at Middle Atlantic Section meeting, R.C.A., Camden, N. J., May, 1944.

creditation. The Institute does not grant nor recommend academic credit, but through its Central Clearing Agency it does assemble all available information concerning the in-service training and experience of service personnel and forwards a complete, Official Report of the data collected to the designated College for evaluation. It is necessary in order to initiate the accreditation service that each service-man make the request by filling out an application form provided by the Institute.

There will doubtless be some of our former engineering students requesting the Institute to submit profiles for courses in such varied fields as radio technician, electronics, internal combustion engines, radar, meteorology, basic training, basic and advanced A.S.T., and many others. To date, however, practically no requests for profiles have come from former students in engineering.

In the case of a correspondence course taken under the Institute program from a coöperating college, the profile will consist largely of a transcript of record with course descriptions supplied by the college. The transcript will also, as usual, state the points credit at which the institution of origin rates the course. There hence will be no problem of credit rating in such cases for the college of utilization, but merely one of credit application. Likewise, in Meteorology "A" and Pre-Meteorology "B" and "C" there will be no problem of credit rating, since the University Meteorological Committee, which administered these courses for the Air Corps, has published a pamphlet giving in detail the credit allowances for the individual courses by the institutions giving them. This pamphlet can be obtained gratis from the Committee, whose headquarters are at the University of Chicago.

The third function of the Institute concerns the administering and rating of tests. The Institute offers to service personnel the following examinations:

1. End-of-Course Tests to determine achievement in specific Institute and Self-Teaching courses. The tests so far set up are mostly on the high school subject level.
2. Subject Examinations, which are designed to measure in terms of subjects usually taught in high school or college, learning gained through study, military training and military experience.
3. General Educational Development, which consists of a battery of tests covering general educational achievement in four major fields, *i.e.*, correctness and effectiveness of expression, interpretation of reading materials in the social studies, interpretation of reading materials in the natural sciences, interpretation of literary materials. Such tests will be given a percentile rating, indicating the standing of an individual relative to national norms for civilian arts college students at various academic levels. It is not likely that such tests will be taken in any sizable numbers by former engineering students, since such tests would not cover engineering subjects outside of mathematics and physics. It would, perhaps, be useful if the Institute could be induced to develop first-class comprehensive examinations covering all of the mathematics, physics, mechanics, and other basic course sequences in engineering, but this is a big order and is not likely to be attempted.

To sum up, then, as far as the first part of our topic is concerned, we may principally expect from the U.S.A.F.I.:

(1) its help in keeping alive the study habit in our former and future students through the medium of the correspondence courses it provides;

(2) its presentation, to a college designated by a service man on his separation from the service, of full and complete information on all in-service courses and training taken by him.

In any concrete case of an ex-service man applying for credit, we have two items to consider. First, how many semester hours are the courses worth; and, second, how can these hours of credit be applied? The latter is the problem presented by the second half of our topic of discussion.

It is easy enough to find printed statements which give advice on credit rating or evaluation. Examples are the pamphlet of the American Council on Education, "Sound Educational Credit for Military Experience"; the Report of the Committee on Credit for In-Service Study of the S.P.E.E. (ENGR. EDUC., Nov. 1943); and the many directives of state education departments and accrediting bodies. Most of these take the Arts College point of view that a degree is purchased by an accumulation of a certain number of credit dollars in the academic mark. This point of view ignores the fact that engineering curricula in general lead to degrees on completion of required courses, including several three- or four-year sequences that cannot be broken.

Most service students who write to us for advice on what to take via A.F.I. correspondence courses in order to hasten their graduation (and we get letters re U.S.A.F.I. courses most every day) fail to realize the time it takes to complete even one 3-credit course by this method. The bulletin of one institution with a long record of successful correspondence course experience states that the completion of "one lesson a week indicates a good rate of progress." Since there are in general eight lessons for each semester hour of credit, this means that a service man would probably not complete more than two 3-credit courses a year. At this rate, the war would have to last six years for a student to complete one engineering college year by correspondence. It is unlikely, therefore, that in-service credits earned by correspondence will be much of a problem in the case of returning engineering students.

Nor is it likely that Army and Navy service schools credit or job credit will bother us much. Total credits for such work would not likely run over ten, and these can be applied to a military science or physical training requirement if needed. Some of the Army or Navy service job training credits might be applied to shop and some laboratory courses. The principal value of such credits to a returning student would be to release time that could be used by him to make up deficiencies or to cope with a program that would otherwise be too heavy if Army life had gotten him somewhat rusty in his study habits.

The Navy Engineering College Program, V-12, should present no credit-application problem, since it so closely follows standard curricula. It is when we come to A.S.T.P. or Navy shorter courses that the real problem of credit application emerges. The S.P.E.E. Committee on Credit for In-Service Study has recommended (see ENGR. EDUC., Nov. 1943, for full report) that when the plan of instruction is not the

same as the regular college system, as is the case in A.S.T., the courses should be recorded without credits but with full information as to program time allotments and contents; as, for example, AST-401 Mathematics, Integral Calculus, 5 class hours per week for 12 weeks. Most colleges giving advanced engineering A.S.T. courses have followed this procedure. It will, therefore, be the problem of the receiving college to evaluate the worth of each such transcript in terms of its own requirements and credit values. This seems a wise procedure, since it permits flexibility in the application of such credits in connection with further degree requirements imposed on any individual veteran and in the light of the individual's academic performance record. To attempt to match individual A.S.T. courses against comparable civilian courses would get one nowhere. In general, A.S.T. courses are abbreviated and short in whole or fractional credits.

Take, for example, an A.S.T. course, Math. 401, Integral Calculus. This course calls for 5 class hours and 5 study hours a week for 12 weeks, or a total of 120 hours. Compare it with a certain civilian course in Integral Calculus which meets 3 hours a week and which calls for 2 hours of study a day and is given 16 weeks, or a total of 144 hours, and rates 3 semester hours credit. On this basis, AST-401 should rate 2.5 semester hours credit. But what are you going to do with the returned A.S.T. man who has had Math. 401? Must he make up one-half credit in Integral Calculus, and if so, how? Besides he may be an "A" student who really knows his mathematics, while his classmate, a 4-F civilian, was a football player when he took civilian calculus and actually put in only one of his theoretical two preparation hours and received a shady "D" in the course.

No, we have got to refrain from that sort of silly academic bookkeeping, in the case of veterans at least. We have got to look at credits more in bulk and get away from the idea that we have to demand exact equivalents in semester hours for each and every course in our curricula. This does not mean, however, that the total requirements of our degree curricula should be lessened. But it will make little difference to a man five years after graduation whether he had a 4-credit course in thermodynamics and a 3-credit course in hydraulics in college, or whether his credits were 3 in thermodynamics and 4 in fluid mechanics. The determining factor should be the total amount of education and the degree of intellectual maturity.

Already many of us are receiving requests from A.S.T.P. students as to what further work they will need for a degree. Here is an actual case, typical in that, like others, there is a hodge-podge of credits. This soldier attended two western colleges and his transcripts show credit for:

Mathematics	15	semester hours
Chemistry	8	" "
Physics	10	" "
Surveying	3	" "
Shop	2	" "
Economics	3	" "
Drawing	5	" "
Electrical Engineering	7	" "
Total	53	semester hours

He was assigned by a S.T.A.R. unit to advanced engineering, Term IV Mechanical Engineering, and completed that term, as well as Terms V and VI, with a "B" average. He wishes to know what he still requires

to earn a degree in Mechanical Engineering.

Now at least two engineering schools that I am in touch with have already rated A.S.T. terms in bulk as about 14 semester hours each. On this basis, our soldier's case sizes up like this:

Previous college work	53 credits
A.S.T. Term IV	8
(Reduced from 14 due to credit duplication)	
A.S.T. Term V	14
A.S.T. Term VI	14
Military Science	8
(Allowance for Army experience outside A.S.T.)	
Total	97

Based on a curriculum requiring about 140 semester hours, this man is deficient to the extent of 43 hours, or about that represented by three 12-week terms. Half of these deficient credits could profitably (as far as the man's education is concerned) be required in English and the Humanities, since the student has no credits in these. Trouble, however, arises when we attempt to fit these, and the other requirements needed to round out the abbreviated Army courses, into a 16-week, 2-semester-system hour program. Subjects are almost certain to conflict with each other, and frequently it will be impossible to assign the student a full standard load.

In our College of Engineering at New York University we are now operating on 12-week terms synchronized with A.S.T. cycles. Our experience so far in handling the cases of several veterans indicates that these shorter terms, with fewer courses given more intensively, lend themselves more readily to efficient scheduling of non-regular programs for the individual than do the normal semesters with their greater number of courses given fewer hours a week. In re-distributing our curricula content from 16-week terms to 12-week terms and in planning hour-schedules for such, we are trying to make it possible for the returning veteran to complete the courses in which he is deficient in the shortest possible time. The E.C.P.D., in its March 1, 1944, memorandum, endorses the use of supplementary terms in the case of A.S.T. graduates and suggests a minimum of four 12-week terms for a student who has had the entire A.S.T. program from Term I through Term VI.

In setting up supplementary terms to round out the abbreviated courses of A.S.T., it is suggested that here might be an excellent opportunity to integrate through comprehensive problem courses the compartmentalized material of the individual courses. For example, three courses are tabulated below with the class hours allotted to them by the Army and a college allotment:

Course	A.S.T. hours	College hours	Difference
Mechanics	72	90	18
Mechanics of Materials	48	60	12
Fluid Mechanics	48	60	12
			42

The thought is that in a situation like this it would be more profitable (educationally speaking) to devote 45 hours to one course which would review, integrate and coördinate the three subjects rather than attempt to piece each course out separately. Similar groupings will suggest themselves, and out of such might come a more complete synthesizing of a student's basic knowledge.

In the last analysis, there is no *one,* or even ten, complete answers to the problem of credit application for the returning veteran. Nearly every case will be a special one and will call for the exercise of considerable judgment, both in credit evaluation and in setting further degree requirements. As has been repeatedly emphasized elsewhere, to give credit to a veteran for knowledge he does not possess, just because he is a veteran, will do no one any good. On the other hand, to be fair to the returning service man who comes back with a hodge-podge of credits, there will be required more than the usual routine credit evaluation of a registrar's office. In a situation such as this, the counseling and placement of veterans who return for engineering can be efficiently done only by those who thoroughly understand the intricacies of, and the relative importance of subject matter in, engineering curricula and who have that understanding of students which only a matured teaching experience can give. To such counselors, when unhampered by arbitrary rules and if possessed of good judgment, can safely be left the job of sizing up the veteran's qualifications and assigning him his proper place in the academic picture.

What Curriculum and Procedure for the Returned Service Man with Partial Undergraduate Education?

By JOHN A. PRIOR*
University of Pennsylvania

The division of topics in this program distinguishes between veterans with and veterans without previous college experience. It may well be asked whether a little college work, say two terms in A.S.T.P., really differentiates these two veteran groups. Probably it does. A veteran of the first group knows how college work is conducted and what is expected of him. He probably came in the first place because he wanted to, he proved himself competent, and he is likely to regard his return to student status as a big part of his homecoming to friends, career, and self-direction. Accordingly his previous college work should simplify the problem of persuading him to assume responsibility for his own education. Should we not, therefore, treat him as a regular undergraduate just so far as possible? This may prove impossible in individual cases; then the solution may be to transfer him into whatever program is developed for veterans of the second group, namely, those without previous college work unless, of course, special problems of rehabilitation are presented. Perhaps the best administrative scheme, one that should be simple and flexible, would be to assign special advisors authorized to build up individual programs from the materials at hand.

Flexibility in matters of detail will be necessary, but no softness in essential requirements is warranted. It will be no kindness to train a veteran for a profession knowing that he can compete only with a handicap. We must expect normal veterans to be mature, diverse, but responsible; we must expect them to be weaker in some ways than the average boy, but stronger in others. Procedure and curriculum should be planned to strengthen the weak points and exploit the strong points. The returning veteran's weakest point is likely to be in grasp of fundamentals. He will have been trained rather than educated; he will have forgotten a great deal; his basic college courses will often have been crowded and hurried. Also, he will have lost something: scholastic habits, mathematical facility, and that mental flexibility so helpful in the study of theory which sometimes makes common sense raise a skeptical eyebrow. Perhaps veterans should not be mixed with kids in subjects like mechanics, thermodynamics, electrical theory; perhaps those who have not studied those subjects before should be assigned to classes with veterans of the second group who have not had previous col-

*Presented at the Middle Atlantic S.P.E.E. Section, Radio Corporation of America, Camden, N. J., May 6, 1944.

lege work and who, therefore, would benefit from the presence of pace-makers in class with them.

For veterans of the first group who had advanced fairly far in their college work, enforced repetition of fundamental courses might prove unpopular to say the least. A solution may be to provide and require nominally advanced courses, for example, Mechanics of Machinery, which would actually involve intensive review of basic material with emphasis on application to more interesting and ultimately more advanced problems. A special merit of such courses is that they prepare men to continue with graduate study of advanced theory, an important responsibility of every high-grade engineering school.

The returning veteran's strongest points will obviously be maturity and experience. The technical phase of his experience is likely to be of relatively little value unless he has been unusually lucky; its equivalent could probably be gained in a year or two of planned industrial training. But under the forced training of intense and intimate living and early responsibility, many a veteran will have learned more of the ways of men individually and in teams than he normally would in ten years of engineering. Certainly, of those who find opportunity in management during the early post-war period, there is good reason to expect a much greater proportion of veterans than of young graduates. Accordingly, there is likely to come a disproportionate share of industrial leadership from the veteran group. The debatable question is: what if anything should we try to do for them as potential managers?

The established formula always seems to begin with the humanistic studies. Whatever effectiveness these may ordinarily have, it is a question whether they will be of the slightest benefit if forced upon practical-minded young men in a justifiable hurry. On the other hand, we have Industrial Management, essentially technical and a standard part of engineering courses which becomes more effective as the student gains maturity and experience. Probably we can depend upon this and the engineering application studies to reorient the veteran's perspective from a world where cost means nothing to our normal competitive economy.

There remains the problem of developing management's ability to exert influence outside of industry. Whether we like it or not—most of us do not—engineers will have to deal with politicians and government representatives more and more. They should be able to interpret the basic needs of industry as clearly as the leaders of agriculture and labor interpret theirs. Otherwise we are in for New Deals and worse deals.

The educational problem at this point resembles that of developing intelligent and active general citizenship for which purpose the critical study of history is usually regarded as especially effective. Much might be accomplished by supplementing this with a similar critical study of evolution of modern industry with emphasis on its economics, its labor and political relations. But this would have to be planned study aimed at definite targets, and not merely shot off in the general direction of vague cultural or social objectives.

From the point of view of teaching in the post-war period, the best fun ought to be found in application subjects. War developments may not revolutionize fundamentals but they certainly will shake the dust out of

many fields of practice. For educational purposes they will furnish fresh material—for analysis, for original design, for experimental projects. For twenty years at least, application courses have been drawn away from specialized training in design or testing with a view toward developing insight and resourcefulness in the application of fundamentals. Now it appears that we shall have to reverse that trend or defend it; and the tug-of-war may begin with the return of the veterans. The general public and new industries, also small and hitherto backward industries, have seen the immense possibilities of direct, concentrated job-training for minor engineering work. Unfortunately they have yet to discover, as the more mature industries have, the definite limitations of specialized training. A fine illustration of the difference of industrial viewpoints is afforded by two recent articles from which I quote below.

In the JOURNAL OF ENGINEERING EDUCATION, March 1944, C. T. Reid, of Douglas Aircraft Company, proposes an engineering course "to meet the real need of the aircraft industry" which, it seems, is more designers to do the 80 per cent of all aircraft engineering now being done on the drafting board. He says, "above all else the changes needed in curricula training our engineers are those changes which will send us men to work as designers. Since what industry needs taught is how metal products are designed for production, industry must provide the opportunity for professional educators to learn factory and drawing room processes and keep up to date." The proposed course turns out to be mainly mechanical engineering, but heavily loaded with application to design of the current type of metal airplane.

The contrasting viewpoint is expressed by Stevenson and McEachron of the General Electric Company, in an article appearing in *Mechanical Engineering*, May 1944. Discussing "Industry's Responsibility for Post Collegiate Education," they say: "new designs to be successful must be based on the fundamentals of engineering rather than on previous design . . . . The native ingenuity of but few men in college during this period (of war pressure) has been stimulated or developed by a basic understanding of engineering fundamentals. Nor have such students been encouraged to think for themselves, in the rush of absorbing knowledge in a very limited field."

There you have most of the debate in a nutshell. Neither type of industry intends to exploit the engineering graduate, but one of the programs will certainly limit his development and opportunities. When the aircraft industry reaches the maturity of the electrical or automotive industry, perhaps ten years hence, not 80 per cent nor 40 per cent of its engineering is at all likely to be done on the drafting board. Many of its best engineering opportunities will probably be closed to men whose training and experience have been limited to design. If this is not so, the aeronautical industry will indeed be a brilliant exception in engineering history. At some point, of course, our students, veterans and boys alike, must be trained for specific jobs. But if we let that training interfere with education we shall be selling their birthright and ours for spinach.

The Amplitude of a Steady Forced Vibration. A Short Method of Evaluation

By H. C. PERKINS

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A damped vibratory motion (with one degree of freedom) excited by a "force" which varies sinusoidally can be expressed by a differential equation of the form

$$M\frac{d^2x}{dt^2}+B\frac{dx}{dt}+Kx=P\sin(\omega t+\theta), \quad (1)$$

in which M, B, K, P, ω and θ are constants, x is the displacement (usually measured from equilibrium position) and t is the time.

The steady forced vibratory motion which persists after the initial free vibration has been damped out is expressed by a particular solution of equation 1, of the form

$$x=A\sin(\omega t-\phi), \quad (2)$$

where x is the displacement from the equilibrium position. The amplitude A and the phase angle ϕ of this steady forced vibration are to be evaluated.

In evaluating A and ϕ it is customary to start with a particular solution of equation 1 of the form

$$x=C_1\sin\omega t+C_2\cos\omega t, \quad (3)$$

which, substituted in equation 1, yields an identity, equivalent to two algebraic equations which are solved simultaneously for C_1 and C_2. Then by a trigonometric manipulation, equation 3, with C_1 and C_2 known, is transformed into equation 2 th evaluating ϕ and A.

This procedure is too involved f some students to grasp readily and i inconveniently long if applied directl to the solution of problems. There i however an interesting method of ob taining the desired results with con siderably less effort.

Starting with equation 2 which i known to be a possible solution o equation 1, the undetermined con stants A and ϕ represent the ampli tude and the phase angle, each o which is to be evaluated.

Substituting equation 2 in equatio 1 the result is

$$\begin{aligned}-A\omega^2M\sin(\omega t-\phi)&\\+A\omega B\cos(\omega t-\phi)&\\+AK\sin(\omega t-\phi)&\\=P\sin(\omega t+\theta),&\end{aligned} \quad (4)$$

which is true for all values of t so tha A and ϕ may be evaluated by subst tuting, successively, two particula values of t, as follows.

Note that when the right side o equation 4 vanishes, A factors out and ϕ can be evaluated directly. Thus in equation 4 give t a particular value t_1 such that $\omega t_1+\theta=0$. It then follows that

$$\tan(\omega t_1-\phi)=\tan(-\theta-\phi)=-\frac{B\omega}{K-M\omega^2}$$

$$\tan(\theta+\phi)=\frac{B\omega}{K-M\omega^2}. \qquad (5)$$

Given the value of θ, ϕ is known. By trigonometry also,

$$\sin(\theta+\phi)=\frac{\pm B\omega}{\sqrt{(K-M\omega^2)^2+B^2\omega^2}}. \qquad (6)$$

Having thus determined the phase angle ϕ, the amplitude A can be evaluated by substituting a particular value of t such that the right side of equation 4 does not vanish. It is convenient to choose t_2 so that $\sin(\omega t_2-\phi)=0$, $\omega t_2=\phi$ and $\cos(\omega t_2-\phi)=1$. Then, solving for A and substituting from equation 6,

$$A=\frac{P}{B\omega}\frac{\sin(\omega t_2+\theta)}{\cos(\omega t_2-\phi)}$$

$$=\frac{P}{B\omega}\frac{\sin(\phi+\theta)}{1} \qquad (7)$$

$$=\frac{P}{\sqrt{(K-M\omega^2)^2+B^2\omega^2}},$$

which is the desired formula for the amplitude.

It is evident that a student can easily carry out all of the details of this short calculation every time he evaluates the amplitude of a forced vibration.

War Time Conversations*

By MAJOR ALBERT J. STOWE, G.S.C.,
Speaking as Personal Representative of
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Father's enjoyment of life-in-the-open was not the only reason my early boyhood was spent on a large home-site. It later appeared that numerous chores were calculated to bring me home from school promptly and thus keep me out of Baxter's poolroom.

Chores sufficed until the end of my first year in high school. Then, Dad interrupted my lawn-mowing to say he had secured me a summer vacation job in the bank. Since the Stowe family was just as curious as the next to know how the Joneses managed everything they did, I burst in on the family dinner circle after two or three days in the bank, with what I thought to be a veritable nugget of news. I challenged Father to guess how much salary Mr. Jones was getting.

"Do you know?" he asked. "Oh, yes sir." And "How do you know?" "Why Dad, *we bankers* know all such things. This is just trivial as compared with other matters that come across my desk every day!"

Normally, Father was a mild mannered man but not on that occasion. He not only declined to hear the information with which I was seething, but then and there delivered himself of a lecture to me with such impact that I shall never forget it. It was on the subject of respecting the confidence of one's employers or one's clients!

This is truly a valuable memory to bring with me into the Army. I share it with you, today, because of its wide application for a people at war. If a guarded tongue was desirable way back in those days with only reputations at stake, how much more important is it that confidences be respected and caution be exercised in conversation *now* that lives hang in the balance.

Every day on buses, on trains, and street cars, in stores and taverns and other places of assembly, there is unloosed enough conversational "dynamite" to conclude this war on a basis vastly different than that which centers our every hope and our every prayer. I am referring to the seemingly unimportant bits of information about military matters that are all-too-easy to hear in entirely too many places. These fragments of information "the latest word from Johnny," or the activity in our port, or the number of planes in a flight, the departure of a Clipper, or what goes on in our factory town, which we may not recognize as the kind of information that

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would be of value to the enemy, are the root of this serious military problem.

It would be ridiculous to suggest that the enemy does not know that Americans have been sent to Australia or elsewhere in force. But how certain are we that they know that Bill's regiment is there? We all realize that one of the important secrets about the strategy in the South Pacific is the number of troops with General MacArthur. What the enemy agent is commissioned to find out among other facts is the total strength of an expeditionary force, the arms and equipment they are likely to have with them and what special training they have had. A word picked up here that Bill is "down under," and then another tip that Ed met Bill there, added to a third word, telling that the two might meet up with Joe, and this spy business becomes as simple as one, two, three.

We must come to the realization that every little bit of military information is of value to the enemy no matter how small. To keep the kind of information I have alluded to, or any other type of fact connected with our war effort to ourselves, means a measure of extraordinary care and even sacrifice for every one of use. None of us ever mean to tell the enemy anything yet some of us do.

Two men in New York were recently sentenced to long terms in federal prison for their activities as enemy agents. One of these confessed to getting his information by hanging around places where defense workers and service men gathered and picking up a chance remark here, another there, and doing it so effectively that he was able to fill out many a picture long-puzzling to German Intelligence.

The enemy's facility in piecing together bits and pieces of information is eloquently borne out by M. Camille Chautemps, several times Premier under the Third French Republic. His comment was contained in a personal letter to a Washington friend of mine, Mr. Robert Freer, chairman of the Federal Trade Commission, who both officially and unofficially, has been effectively helping us warn civilians concerning the dangers of LOOSE TALK. M. Chautemps, who is now residing in America, wrote in parts as follows:

"You are perfectly right in your analysis of the process by which some news which seems very unimportant to the men who are talking about it becomes dangerous when it is collected by clever enemy agents.

"I saw, one day, a German document in which the information needed by the German propaganda machine had been divided into 3,000 modest questions, apparently inoffensive, but the combination of which was sufficient for giving the Germans a complete picture of essential matters about the French situation."

I was present, recently, at an espionage trial in Detroit, and heard things that makes us shudder to even read about. A government witness, a woman who had pleaded guilty following her apprehension by the Federal Bureau of Investigation, was testifying. She told how in Budapest, early in 1941, she had been hired to come to the United States as an espionage agent. Then followed an account of how she had been sent to Berlin for special training and instructions.

She testified to having been ordered to send back all manner of information, irrespective of how seemingly trivial. In fact she went right down the list of all those things that we have been warning people not to discuss ever since Pearl Harbor.

How do these things get out? Almost always through carelessness. Sometimes a soldier talks. Sometimes his wife talks. Sometimes it is a clerk in a grocery store, or a bartender, or a draftsman, or somebody in a service organization, or perhaps a stevedore who has helped to load munitions for overseas shipment, or the head of a great industry, or a banker, or an insurance agent. In other words, a cross section of the most talkative nation on the face of the earth—a nation which values its free speech, a nation which has never had to suspect its neighbors, or question its friends, whether those friends live across the border or in the next block or in the next apartment.

It is not necessary to remind me that indiscretions are not limited to civilians; that we in uniform are not blameless. You may have encountered both officers and men who lacked caution regarding military information. Naturally, since most of the men in our armed forces were themeslves lately civilians, they have the same need as you to be educated on the seriousness of security of military information. You may be assured they are getting such education in far more intensive ways than you realize. Morning, noon, and night as soon as a man dons uniform, he is made continually mindful he must guard his tongue.

Bear in mind that putting a uniform on an individual does not necessarily change his human nature over night. A braggart in khaki as in mufti, finds it pretty hard to admit that he isn't thoroughly "in the know."

One brief illustration will indicate how rapidly the enemy has been able to gather information and get it to his headquarters.

When Brazil declared war on the Axis, the German radio in Berlin made a broadcast in Portugese to Brazil. "We're not worried about Brazil's declaration of war," the Germans said, ". . . your soldiers are a lazy indolent lot. And if you don't think so," they continued, "go down to a certain wharf where Private So-and-so is supposed to be on guard duty. He's supposed to be guarding valuable military supplies, but the fact is that he is asleep behind some packing cases near the end of the pier." Brazilian staff officers drove immediately to the spot the Germans had described. And there, sure enough, was the soldier sound asleep in the exact spot the Germans had mentioned. Now, at the very most this man's total period of guard duty was four hours. Furthermore, in that time he had to be assigned his post, make a show of patrolling it until he was alone . . . find a concealed spot . . . and then go to sleep. What's more, a German agent had to see him there . . . and send the news to Berlin . . . the news had to be edited, translated, and fitted into the broadcast . . . and then radioed back to South America. All within four hours at the most! That's how fast news is handled by our enemies the Germans! While you're on a shopping trip, you could tell a friend an interesting bit of news about your boy . . . and before you get home German Intelligence officers could be studying that news in Germany.

INVASIONS are in progress, and it is simply common sense to realize the enemy has to redouble his espionage efforts. He seeks to anticipate our points of penetration in order to meet us with force. Only a few hundred people in various parts of this country, and in varied occupations, any of

you included, each contributing his little bit of LOOSE TALK can provide the enemy with all he needs . . . a jig-saw puzzle picture of our invasion plans. SILENCE on the part of every one of us was never so necessary as in the months to come.

THIS war is realism on the most awful scale ever known to man. While it is global in its vastness it is as intimate as the tiniest home in our land. There's nothing the least bit abstract about war when it enters the home. Then and there it takes on mightily individual proportions. Its stark tragedy is bitterly personalized by every name on the casualty list. Then, we're not smug any more; no longer complacent. We don't feel that war's demands must be tailored to our individual, personal convenience . . . that it is a part-time matter. At this point, we readily curb our impulse to chatter carelessly (and resent it among our neighbors), fully awake to the hazard loose talk puts in the way of all loved ones . . . bound and determined that we won't have on our conscience any of those names on the lengthening casualty list.

We're in a game now where every hit has got to be a "homer"! Until the final play is over we mustn't relax for a single moment.

Until this fight is finished . . . cautious conversation is simply one thing we expect of each other. Other opportunities to help on the home front are varied and abundant. Big things we've got to remember; we can't escape this war-torn world by wishful thinking; we can't walk out on the game.

WE'VE got to stay in there with everything we've got! And even though the present score seems running in our favor, it is just as well to pass the word: "GENTLEMEN: THIS AIN'T NO TIME TO BUNT!"

Education for Post-War Industry*†

By R. E. ORTON

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In presenting the subject which I propose to discuss I am guilty of a great breach of good diplomacy—telling the other fellow how to run his business. For this, I am afraid, is exactly what I have in mind. I feel that some features of our system of engineering education are inadequate. I want to point these out, and to offer a remedy. To qualify myself for this job I will state that I have never taught in my life, and know nothing whatsoever of teaching. Certainly, then, I have every right to tell *you* how, and what *you* should teach.

Today the basic requirement of a candidate for admission to an engineering department is that he, or she, be capable of adding fractions. . . . Literally, to such a point has the tremendous demand brought on by the war lowered standards. Correspondingly, schooling has had to be directed toward the application of mass training methods to give the largest possible yield. While this is quite proper in a time of emergency it must not be assumed that it will suffice in the post-war era.

While the pre-war depression did not produce a quantity demand with its lowered standards, economical stringency was such that every student wanted his training "practical." He tested every study by the criteria of the direct financial return he could hope to secure from its later application. This was supported by a similar demand from industry. They felt that they had no money to spend on theory; but must see a quick and sure return from their investment in personnel.

The post-war period, on the contrary, will see a demand for advanced engineering training. The mass production of today has furnished all the "practical" engineers that can be used. Industry has had the opportunity to see the rewards from the application of sound fundamental thinking to such an extent that a definite and growing appreciation of such training has developed. Aircraft, ship, tank and ordnance construction of an intricacy and variation beyond anything ever dreamed of has necessitated sure and adequate engineering thinking. Shortages of materials in all lines have taxed the designers' skill to the utmost and required more adequate stress analysis in all fields. Industry, seeing this development, will be quick to turn it to its competitive advantage in the post-war markets, and will demand technicians that can give them that advantage. If the student of the future is to be able to compete in

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the engineering market of the future he must be inculcated with the type of training which will either give him, or permit him to develop, more advanced engineering thinking.

The March issue of *Mechanical Engineering* carried an article by Elliott Dunlap Smith of Yale University on "Industrial Inventiveness." An unusually well thought out article analyzing not only the requirements for inventiveness, but the requirements for advanced engineering thinking of all types. I would like to quote in part from one paragraph which so well epitomizes the thought:

"The most important way . . . is to make education and experience more fundamental. If in school and at work the resourceful young engineer is required to shun memorized formulas and to go back to basic principles for the solution of his problems, the process of developing technical competence will in itself give him the basic understanding and way of thought essential for inventiveness. When logic thus goes back to fundamental origins, and is in that sense original, logical development and inventive insight come close together. Both make possible fundamental shifts to more profound bases of approach."

Dr. Almen, of General Motors Laboratory, has frequently accused the engineering profession in general of "still believing in Santa Claus." I am afraid that there is a good deal of truth to this. We are entirely too inclined to make computations based upon formulas about which we know too little, and carelessly and heedlessly arrive at unwarranted conclusions. Even when met with failures we are inclined to shrug them aside and not look the facts in the face. We feel that a few simple formulas offer us the key to the entire physical universe, and with these keys we proceed blissfully on our way. A few examples of this practice are described below.

It is fondly believed that by the simple expedient of pulling tension test bars and measuring some one of the failure values the strength of a material for a given application may be determined. We leave scarcely a doubt in the student's mind on this score, and yet we all know that there simply is no such thing as a "simple stress" condition. Any real problem is far too complex to be fully measured by such tests.

Now, I do not mean that these tests do not have value. They are certainly better than nothing. But it is simply folly to assume that the entire answer lies here, and the use of such figures without appreciation of their limitations is suicidal.

We examined recently the fractured tow bar of a truck trailer. Apparently, it was believed that all that was necessary to design this part was to divide the draw bar pull by the cross sectional area and compare that figure with the value obtained from a tensile test. A small fillet, and an abrupt change from small section to large was given no weight. Moreover, the attempt was made to solve the problem by changing to a heat treated alloy steel, without recognition of the high notch sensitivity to fatigue of such steels. Nothing that the designer had absorbed from his training had led him to suspect such a thing.

In the case of a punch press crank shaft recognition was not given to the stress condition existing at a press fit, to say nothing of the effect of an abrupt shoulder with a sharp fillet. The result was a fatigue failure, even

though the material employed was a relatively low carbon steel.

The conventional shaft problem as given in school is a uniform cylinder with unbroken section. In a case typical of those found in industry slots pass clear through the shaft; but so far as the student is concerned it is still Mc/I and Tr/J. With amazing frequency is the square shaft designed on the basis of its polar moment of inertia. Also rectangular shapes, angles, I beams and what have you. Curved beams are figured just the same as straight. The student's formulas still give an answer, so why should he worry!

Now, we cannot anticipate that every graduate shall be competent to handle every design or other engineering problem with which he is confronted. Nor do we ask it. We do feel, however, that he should have some appreciation of the limitations of what he has learned. He should be less trusting and more trustworthy. Now, without any doubt each one of you have from time to time pointed these things out to your students. But they don't seem to learn them. Why?

It seems to me that the foundation of this trouble lies in the attitude we instill in the student at the time we are educating him. We make it all too simple and too easy. We give him simple equations into which he can substitute his quantities and come out with an answer. He is not taught to have doubts and uncertainties; he is not taught to question. Yet when he gets out into the industrial world, if he is to make a successful engineer, he must question every piece of information that comes to his hand, and doubt every design that he considers. For there is no job in industry as simple as our conventional text book problems.

In particular, does the teaching of strength of materials need to get down to the fundamental premises. This basic subject is taught too much as a collection of rules. Why can't we start out by teaching elastic theory—in the very beginning? Not every complex detail, nor all of its many unrelated problems. Simply the underlying principles. If the student comprehended the general state of stress at a point, and the variation in the stress with change in stress direction, his appreciation of stress distribution in any real problem would be greatly enhanced. His application of analysis to real problems would not be so sure, but it would be a great deal more reliable. Knowledge of the boundary conditions alone should permit of an appreciation of the difference between circular, square, and irregular shaft sections. Of the effect of changes in section, sharp fillets and so on. The student would understand that the vicinity of a concentrated load or of other load discontinuity must present a disturbed stress pattern.

You may feel that the mathematics offer too great a difficulty for the elementary student. I don't believe it needs to. Elementary elastic analysis may be taught without introducing any more mathematics than that customarily included in the four year course. We will need simple, elementary differential equations, and an understanding of partial derivatives, such as is customarily included in undergraduate courses in calculus. We have a tendency to shy away from calculus, we are always afraid it is too difficult for the student. I think we should collectively make up

our minds on this score. If it is too difficult, it should not be taught at all; if it is not and is to be taught, then it should be used. I don't think the subject needs to be difficult, and perhaps if we actually applied it it would be better understood by the student. However, let's examine a tentative course in elastic analysis as it might be given, considering such questions as the mathematics involved, the difficulty of the concepts, and the value of the ideas to the student.

The course would open with a discussion of the position of stress analysis in the field of mechanics and engineering, the better to orient the student. This would be pointed up with a detailed discussion of the "failure problem," solution of which is the prime purpose of stress analysis. The impracticality of field testing would be pointed out, indicating the need for stress analysis and testing of materials. Strong emphasis should be placed upon the fact that the development of analysis is by no means complete and probably never will be, and that at times it is necessary to fall back on experimental methods as better than nothing.

Next, an introduction to material characteristics pertinent to analysis. The necessity of assuming, for the purposes of computation, an idealization of the characteristics should be carefully pointed out; and great stress laid upon the defects of actual materials and our lack of knowledge of exact qualities. This would cover Elasticity, Elastic Limit, Hooke's Law, Proportional Limit, Homogeneity, Isotropy, Initial Stress, Body Forces, Continuity of Stress and of Strain, and last, Superposition of Stresses and Strains. The attempt should definitely be to create an attitude of doubt and uncertainty, conceding quite frankly the points where our knowledge is weak. Such a treatment will stimulate and provoke reflective thought. This should be concluded with a justification for the use of methods admittedly so deficient —recourse being to the old "it works" proposition.

Next, the concept of stress as distributed internal force is introduced in detail, followed by a discussion of the general condition of stress on an element of area at any point of a plane, oriented at any angle. It would be well to point out that the stress may be described in terms of the resultant and its inclination; or in terms of normal and parallel components; or in terms of components parallel to the coördinate axes. This could well be illustrated by three dimensional models. Such a discussion should leave the student's mind free from any idea of a "directional property" of stress, such as is connoted by the term "fiber stress."

Then follow with an analysis of the equilibrium between the stresses on a sectioning plane and the loads on the sectioned portion of the body. Equilibrium problems are familiar to the student from his study of "statics," so this is an easy step. It also leads to the study of the directional variation of stress and the stress equilibrium equations. Simple compression loading could now be analyzed, but it should definitely not be a column with a concentrated load, but a short prismatic bar with uniformly distributed loads on the two end faces. It may be shown that the stress is uniformly distributed without recourse to mathematical analysis. Uniform tensile loading would serve

to illustrate stress sign. Then "simple shear," demonstrating the equality of stress on mutually perpendicular planes. This would be followed by an analysis of the strain developed by these simple load conditions, introducing the elastic moduli and Poisson's Ratio. Volume change will now illustrate well the approximation usually made in strain superposition. Conclude by pointing out that load conditions must be faithfully reproduced to obtain the desired stress distribution.

This discussion will have matured the student's concept of stress and strain. It could well be rounded out with "working stresses" and physical testing, preparing him for an introduction to the basic relationships of analysis.

Stresses acting on mutually perpendicular planes at their common point, in terms of normal and parallel components, should now be described. This is best illustrated by the elemental prism, using a three dimensional model. Nomenclature and positive directions for orientation parallel to the coördinate planes may then be introduced. Now "plane stress" is demonstrated, the first portion of the course being, in the main, confined to two dimensional analysis, permitting a grasp of the fundamentals by the use of this less complex system.

Next (Fig. 1), an analysis of the variation in the stress acting on a plane with variation in its orientation. Again we do not introduce a new idea to the student, merely the application of the old idea of equilibrium in a new way. Using a triangular prism having its two arms parallel to the coördinate axes, and employing only stress components parallel to the axes, will permit of a very simple demonstration of the principal stress directions. Then, by reorienting the prism so that the arms are in the principal directions, we may in simple fashion establish the "ellipse of stress." This is an excellent concept to convey an appreciation of stress variation with direction. Three dimensional ellipsoid of stress may be introduced by statement, leaving the derivation to advanced analysis. Plane stress is then the special case of the three dimensional stress system where S_3 vanishes, the ellipsoid "collapsing" to an ellipse. In simple tension the ellipse collapses into a straight line. Stress, in all cases, it may now easily be demonstrated, exits on planes at any angle.

From the ellipse normal and parallel components may be derived, and from these the principal stresses in terms of the stresses in the coördinate directions. If it is felt that the time can then be spared it may be desirable to introduce the Mohr's Circle diagram. After this demonstration no student's mind should be tied down to stresses in what are, after all, but arbitrarily chosen reference directions.

The next step is the "boundary conditions," which are but a special application of the figure in the upper left of Fig. 1, the hypotenuse now representing a segment of the boundary. Some time spent considering the special conditions of a free boundary and a boundary carrying only a normal load will illuminate surprisingly the entire stress problem. Under both these conditions the principal directions are parallel and perpendicular to the boundary, and in the first case the perpendicular stress is zero. An understanding of boundary conditions will help to an appreci-

ELLIPSE OF STRESS
PRINCIPAL STRESS DIRECTION

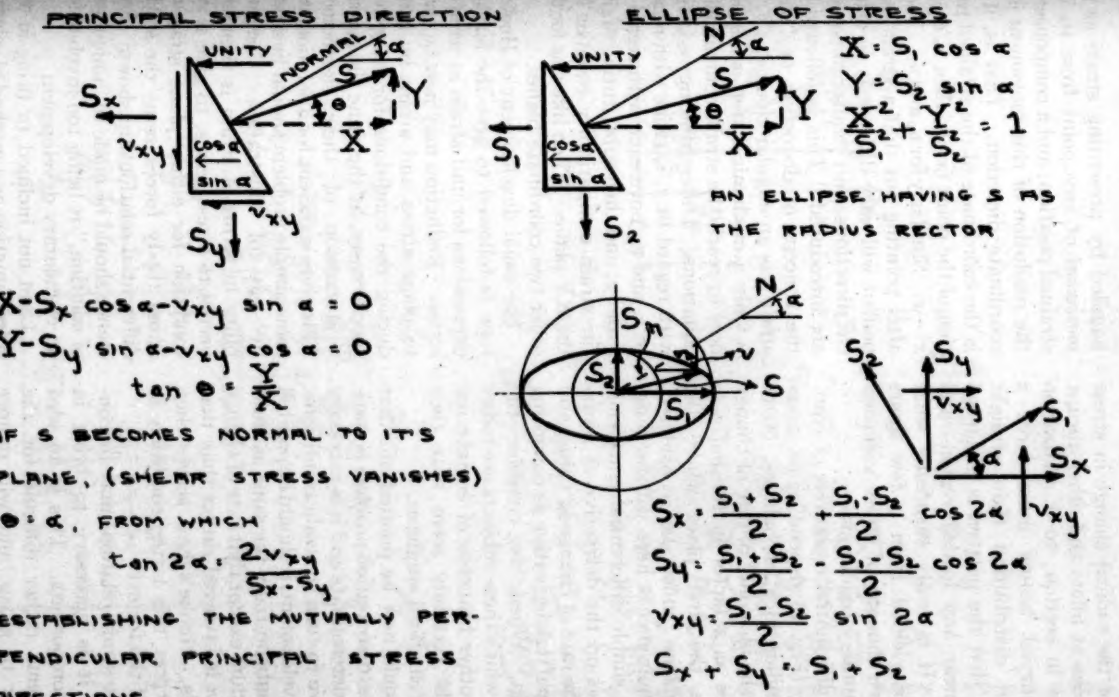


FIG. 1. Variation of stress with directions.

ation of the radical change in stress conditions at fillets and other abrupt changes in section; to a realization that curved beams must have a different distribution than straight beams; that the pattern is disturbed at or near any loaded region—and so on. It is really surprising what may be yielded from a few hours reflective thought of stress variation and boundary conditions.

The differential equations of equilibrium (Fig. 2) depend again upon the familiar idea of balance, introducing the idea only of rate of change in stress as a factor in the balance. This is the first place where the mathematics must be considered. Our requirements here will be satisfied by simple differential equations, emphasis on the derivative as measuring the rate of change in value, and on the partial derivative as connoting direction. When we consider the uses to which these subjects are today put in other branches of engineering it would certainly seem that they could well afford emphasis.

It should now be pointed out that the stress distribution problem is statically indeterminate and it is necessary therefore to turn to strain conditions. This development, it should be pointed out, is substantially the same as *stress* equilibrium except that rate of change of *strain* is involved rather than that of stress. Hooke's Law serves then to interpret this latter condition in terms of the former.

Before strain relations may be considered it is necessary to bring in strain components. This is an idea that seems rather difficult for the beginner to grasp, and will require considerable care and thoughtful layout of instruction to make thoroughly clear. However (Fig. 3), this may be handled by presenting strain as the *movement* of any point from its unstrained position; and a component as the resolution of this movement in a coördinate direction. That is, if x' is the coördinate of the strained position of the point (x, y), then u_x equals $x' - x$. Similarly for u_y and u_z. Then, after pointing out that a strain component will vary differently in different directions, unit strain components are introduced. This is followed by the concept of distortion or "shear strain" as an angular change.

Only a mechanical step is required now to reach the strain compatibility equations. Differentiating ϵ_x twice with regard to y, ϵ_y twice with regard to x, and v_{xy} once each with regard to x and y; and then substituting to give the strain compatibility equation for the XY plane. Then likewise for the other two coördinate planes.

The usual development of Hooke's Law is followed to give the familiar expressions for unit strain in terms of stress. Reduction may now be made to plane stress and strain by introducing the conditions for these two special cases, at the same time giving a discussion of their significance. This gives sufficient for a solution, and some simple problem should be solved by way of illustration. Compatibility in terms of strain is then converted to stress terms, to give as the condition for either plane strain or stress (body forces zero) the simple differential relationship shown. Reference should be made to "uniqueness of solution," it being too involved for an elementary development.

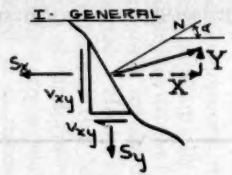
I am not inclined to bring in the stress function as a method of solution in elementary analysis. It is not necessary, we have sufficient without it, and it is a rather difficult point to

FIG. 2. Derivation of stress differential equations.

FIG. 3. Strain components and compatibility.

BOUNDARY CONDITIONS

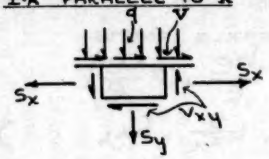
I. GENERAL



$X = S_x \cos\alpha + v_{xy} \sin\alpha$

$Y = S_y \sin\alpha + v_{xy} \cos\alpha$

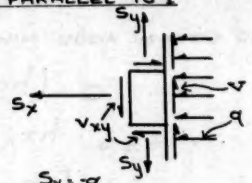
I·A PARALLEL TO X



$S_y = -q$

$v_{xy} = v$

I B PARALLEL TO Y



$S_x = -q$

$v_{xy} = v$

II · STRESS EQUILIBRIUM

$$\frac{\partial S_x}{\partial x} + \frac{\partial v_{xy}}{\partial y} = 0$$

$$\frac{\partial S_y}{\partial y} + \frac{\partial v_{xy}}{\partial x} = 0$$

III · COMPATIBILITY

$$\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)(S_x + S_y) = 0$$

PLANE STRESS OR STRAIN, BODY FORCES ZERO

STRAIN ANALYSIS

PLANE STRESS

$$\epsilon_x = \frac{1}{E}(S_x - \lambda S_y)$$

$$\epsilon_y = \frac{1}{E}(S_y - \lambda S_x)$$

PLANE STRAIN

$$\epsilon_x = \frac{1+\lambda}{E}\left[S_x - \lambda(S_x + S_y)\right]$$

$$\epsilon_y = \frac{1+\lambda}{E}\left[S_y - \lambda(S_x + S_y)\right]$$

$$u_x = \int \epsilon_x \, dx + f_1(y)$$

$$u_y = \int \epsilon_y \, dy + f_2(x)$$

SUBSTITUTE u_x AND u_y IN $\frac{\partial u_x}{\partial y} + \frac{\partial u_y}{\partial x} = v_{xy} = 2\frac{(1+\lambda)}{E} v_{xy}$ TO SOLVE FOR f_1 & f_2

FIG. 4.

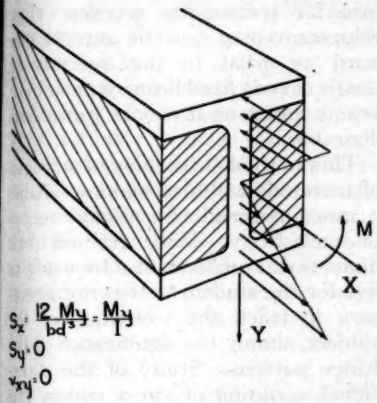


FIG. 5. Beam in pure bending.

grasp. Using what we have without this aid better serves our purpose because it holds closer to fundamental requirements. These requirements, which must be met by any stress system, are summed up in Fig. 4 along with the essentials of strain analysis. As may be seen, the mathematical needs for an understanding of the fundamentals of elastic analysis are, after all, quite simple.

Analysis for the distribution of stress in a rectangular beam in pure bending may now be made. This may be handled by either assuming linear variation in S_x, proving it by substitution in the fundamental equations; or worked back from the boundary, stress, and compatibility conditions. Then present Saint Venant's principle, emphasizing it sufficiently so that it will be appreciated that the theoretical problem is, at best, but an approach to the practical. Now follow with the strain analysis of this condition. Then a cantilever beam loaded at its end. The strain analysis here illustrates the importance of the "fixed" end condition. Next a simple beam with a uniformly distributed load. In this analysis the value of the S_y stress in terms of the S_x should be illustrated, showing that it becomes small as the beam becomes relatively long.

From this the conventional analysis of bending moments and shear on a beam, and then the analysis for any condition of bending or shear. The strain analysis leads to the differential equation of the elastic curve. This completes the analysis of rectangular beams.

The transformation to beams of other sections, in the case of uniform bending, is illustrated in Fig. 5. The removal of the superfluous material (shown crosshatched) is justified because the stress across the severing planes is zero, so that its removal does not change the distribution. When shear is present, as in Fig. 6 a traction loading on the inside of the flanges is required to maintain the shear distribution. From the parabolic distribution of the shear in rectangular sections it is known that these will be very small if the flanges

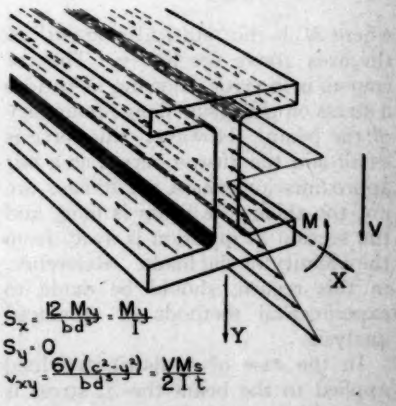


FIG. 6. Beam with bending and shear.

are not too heavy, and an approximation is made by ignoring it. The shear distribution is then found somewhat as in the usual way, except that the differential equation is obtained directly from the equilibrium equation, as—

$$\frac{\partial v_{xy}}{\partial y} = -\frac{\partial S_x}{\partial x} = -\frac{y}{I}\frac{\partial M}{\partial x} = -\frac{V_y}{I}$$

and since V and I are constant and v_{xy} doesn't vary with x,

$$\left[\frac{\partial v_{xy}}{\partial x} = -\frac{\partial S_y}{\partial y} = 0\right],$$

this may be changed to

$$\frac{dv_{xy}}{dy} = -\frac{V_y}{I}.$$

Now, substituting $dy = da/t$,

$$v_{xy} = -\frac{V}{It}\int y\,da + c_1.$$

c_1 is determined by the condition $v_{xy} = 0$ when $y = c$, giving finally

$$v_{xy} = -\frac{V}{It}\int_{y=y}^{y=c} y\,da = -\frac{VM_s}{It}$$

where M_s is the "statical moment" of the area above the line y. This, of course, is in error, showing as it does a stress on the inside flange boundary of the beam. However, this force is small and the answer serves as a fair approximation where the flanges are not too thick, the beam is long, and the section in question is away from the vicinity of the loads. Reference, in this regard, should be made to experimental methods of advanced analysis.

In the case of a distributed load applied to the beam the S_y stress is ignored, as per the discussion of this case for rectangular sections. Development may now be carried forward as usual to the analysis of elastic curves, fixed beams, continuous beams, and so on as may be considered desirable.

This method of teaching of strength of materials will also make available a most powerful educational tool—photoelasticity. With its aid two dimensional problems can be made to live for the student. It is not necessary to teach the technique of the subject, simply the significance of the fringe pattern. Study of the directional variation of stress makes this possible as fringes show the difference in the principal stresses, and the isoclinics the principal directions. Also, from the free boundary conditions, the fringe pattern shows the parallel boundary stress directly. Illustration would be by photos, and by motion pictures of progressive loading; or by actual model demonstrations.*

This outline has only sketched in the handling, and the educational possibilities of the teaching of elastic analysis. It is offered more for provocative thought than as a fully complete scheme. An important feature of it that has not been stressed is that it leaves the student, after completing the course, mentally free to advance in his study of stress analysis, while still giving him the basic knowledge contained in the conventional program. It is suggested that consideration be given to teaching, in this fashion, to a select group as an experiment in a novice's ability to absorb these ideas. It is felt that such an experiment will lead the way

* A number of photoelastic pictures illustrating simple strength problems followed. Because of lack of space they are not reproduced.

to the universal application of this essentially sounder approach to strength of materials.

While I do not believe that a critical analysis of other engineering subjects would indicate the need for as drastic a revision as has this one, I do believe that, by somewhat the same methods, more original and reflective thinking could be developed.

It must be remembered that what industry requires from an engineering graduate is not a large store of technical knowledge. After all, there are a host of reference works from which we can secure such material. What industry does require is the ability to think and your courses should be designed to stimulate thought. Thought is not stimulated by presenting any subject as the last word. Thought is stimulated by emphasizing what is *not known*, just as much as by emphasizing what *is known*.

The Carnegie Social Relations Program*

By GLEN U. CLEETON

Director, Division of Humanistic and Social Studies, Carnegie Institute of Technology

That professional education for engineering should develop awareness of problems of social relations, should develop the capacity of outlining and analyzing such problems with more than usual clarity of insight, and should develop the ability to propose objective, rational solutions to such problems is a fundamental premise underlying the Social Relations Program at the Carnegie Institute of Technology. That traditional engineering curricula, even when catalyzed by a sprinkling of courses in the liberal arts and social studies, do not accomplish these ends is a secondary but almost equally important premise.

Engineering education has not ordinarily developed either the ability to foresee social problems likely to be created by advancements in science and technology or the willingness to accept responsibility for contributing to their solution. Dr. Alexis Carrel in his suggestive book, *"Man, the Unknown,"* † presents a thesis which might well be accepted by engineering educators not only as a charge of evasion of responsibility, but also as a challenge to those concerned with the planning of engineering education. Says Dr. Carrel: "Man should be the measure of all. On the contrary, he is a stranger in the world that he has created. He has been incapable of organizing this world for himself, because he did not possess a practical knowledge of his own nature. Thus, the enormous advance gained by the sciences of inanimate matter over those of living things is one of the greatest catastrophes ever suffered by humanity. The environment born of our intelligence and our inventions is adjusted neither to our stature nor to our shape."

Further support of the thesis that technology has developed beyond our capacity to utilize its fruits intelligently may be found in the writings of such leaders in social thought as Lewis Mumford, Charles Beard, J. D. Bernal, William Ogburn, Waldemar Kaempffert, Walter N. Polakov, Arthur Pound, Elton Mayo, and John Dewey, to name a few. It is also evident in the popular writings of such publicists as Stuart Chase, in the reports of the National Resources Committee, the Temporary National Economic Committee, and other government affiliates, and in the contemporary views of present-day industrial and business executives who support such organizations as the National Industrial Conference Board and the Committee for Economic

* Paper presented in part at the Fifty-second Annual Meeting, S.P.E.E., Cincinnati, June 22–24, 1944.

† Harper and Brothers, 1935, pp. 27–28.

Development. It is toward the thinking of such men that we direct the attention of our students in their courses in social relations rather than to the didactics of textbook courses in introductory economics, political science, psychology, and other commonly chosen courses which have heretofore constituted the "free electives" of traditional engineering curricula. We choose to introduce our students first to the study of social problems which have been worthy of thought and study by men of more than ordinary mental stature and then permit the student to seek the theories, principles, and facts relating thereto, rather than follow a plan of cramming the minds of students with theories, principles, and sufficient information to pass a final examination. This latter method, which we abandoned five years ago in favor of the problem, project, and integrated social studies approach, fails because the basic assumption of value in stored knowledge is false.

In the free elective system the student usually pursues a miscellaneous group of introductory courses organized on an apprentice or orientation level for liberal arts majors. If this does not happen, the student frequently concentrates most of his electives in the field of economics because his faculty adviser is convinced that economics courses have practical value. In either case the student usually completes his college career and graduates unaware of his responsibilities as a citizen and almost completely disinterested in social problems which are closely related to the professional contribution which he as an engineer will make.

Dr. Karl T. Compton, in an article entitled "Engineering in an American Program for Social Progress,"* has drawn attention to the contribution which the engineer might make in the solution of social problems. He emphasizes engineering method and points out that persons directing men and controlling forces and materials of nature for the benefit of the human race will succeed "to the extent to which they follow the methods of the engineer —in basing policy upon facts, in utilizing knowledge to achieve results, depending on law rather than hunch, in giving attention to foundations before erecting superstructures, in using imagination disciplined by experience, in thinking through to the goal before starting on the way—to this extent will their efforts be for the benefit of the human race." It must not be assumed from Dr. Compton's remarks that engineering training alone will fit one to grapple with social problems. The transfer of discipline, which might be expected, simply does not occur in the majority of cases. In fact, experience has shown that engineering discipline may produce little more in its recipients than a tendency toward ultraconservative, stereotyped responses to social issues. Unfortunately the human mind has a deep affinity for analogies, and the approach to the solution of social problems by an engineer often fails because he reasons by analogy, from materials to men and vice versa, without recognizing that problems relating to man and the social structure of which he is a part call for a higher level of mental process than analogy.

There is a distinct difference between the analysis and solution of engineering problems and the analysis and solution of social problems in that there are usually two or more equally

* *Science*, Vol. 85, 1937, pp. 276–280.

valid solutions to social problems. Teaching the student why this is true, showing him how he should proceed in clearly stating a social problem, making clear how one can obtain valid data and make an unbiased analysis, how to carry on a step-by-step solution, arrive at an acceptable conclusion, and test that solution against experience is a fundamental task of instruction in social relations. This is an accomplishment that we have found cannot be expected as a by-product of engineering training, nor can it be achieved by a system of free electives in liberal arts and social studies.

The Social Relations Program at Carnegie Institute of Technology is an outgrowth of an educational experiment begun in 1933 by President Robert E. Doherty when he was Dean of the Engineering School at Yale. While there Dr. Doherty experimented with social relations project-seminars for junior and senior engineering students. When he came to our institution, he encouraged our staff members to undertake further experiments in social relations instruction on a broader scale to include work in all four years of all curricula in the College of Engineering. To make such an experiment possible he sought and obtained financial aid from The Maurice and Laura Falk Foundation. In presenting the case for need for education and research in social relations to the Falk Foundation, Dr. Doherty clearly outlined the educational problem involved:

> In planning a revamped educational program for engineers, what are the fundamental considerations from which our thinking should proceed? Unquestionably we must start from the premise that competent citizenship is the first responsibility, and that the more the individual's educational opportunity is extended, the greater this responsibility. Competency as a citizen requires more than a preliminary knowledge of the origin, purpose, and form of our government, the early disposition to cooperate and accept majority opinion, and the other attitudes cultivated in the first levels of education. It requires, as well, especially of the better minds that have had the privilege of higher education, an understanding of principles and forms of government, a cultivated ability and attitude to weigh, with respect to the best interests of American democracy, the complex issues that arise; and some feeling of obligation to decide intelligently and give support to the decision. Our experiment in democracy rests foursquare upon the assumption that the citizens themselves are competent to settle issues wisely. If more professional people, who presumably are trained to think, do not take interest in these matters, then the future talent exercised upon the problems of state will be essentially what it has been, and the end result is clear. The American experiment is too great, its ramifications too complicated, its values too precious to be guided by emotion and selfish interest. A successful issue of the experiment demands guidance that is based on intelligent, dispassionate study. And this cannot come from a mere handful of men; it must, by the very nature of democracy, come from large numbers. So, in my opinion, if we are to endure as a free nation, we must think educationally in these terms.
>
> There is a second fundamental consideration of equal importance. Not only as an educated citizen but also as a practicing professional man, the engineer has heavy social responsibility, and he cannot escape it. His own creation of the onrushing technological tide has swept him into a commanding position where his plans and decisions may have pervasive social implications. He has been the only one who could cope with the technical side, yet he has not been properly prepared on the social side. It

is widely assumed, however, that an engineer who is trained to think straight on technical matters regarding materials, costs, and physical laws can do so on problems involving social elements as well. I know no greater fallacy, nor greater cause of mischief. You can't put a human being in an equation, and you can't develop over-night humane appreciation in a mind that has been cramped almost wholly within the bounds of technology during the four formative years of higher education. So I repeat: the engineer has been thrown into command unprepared.*

In 1938 The Maurice and Laura Falk Foundation made endowment provisions for the establishment of the Maurice Falk Professorship in Social Relations, and Dr. Willard E. Hotchkiss was appointed to fill that position. Under the leadership of Dr. Hotchkiss a four-year integrated program of instruction in social relations has been developed. The first group of engineering graduates to have studied the full program finished their work in December, 1942. While the program is far from being finally crystallized, we have had sufficient experience with it to have learned many things which may be of interest to others hoping to develop similar programs.

When we began work on the problem of providing a four-year program in social relations, we had certain purposes in mind. Later when we found that these purposes were closely akin to the objectives outlined for the humanistic-social stem of engineering education by the Committee on Aims and Scope of Engineering Curricula of the Society for the Promotion of Engineering Education, we adopted those objectives and have shaped our instruction in social relations toward those ends.*

We have tried to develop an integrated program in social relations drawing instructional materials from various fields of knowledge and presenting those materials to students through the problem, group discussion, and individual student report methods of instruction. The topics of study in the freshman year are "Technology and Society" and "Intellectual Tools" and in the sophomore year, "Problems of Population and Natural Resources." In addition to the direction of study toward problems inherent in the general topics indicated for the freshman and sophomore years, effort is made to develop understanding of certain economic, psychological, political, social, and legal concepts. The work of the

*Doherty, Robert E., *Education and Research in Social Relations*, Carnegie Institute of Technology, December 1937, pp. 1–2.

*As reported in the JOURNAL OF ENGINEERING EDUCATION in March 1940, the objectives recommended for the humanistic-social stem of engineering curricula are as follows:

1. Understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development.
2. Ability to recognize and to make a critical analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose toward these ends.
3. Ability to organize thoughts logically and to express them lucidly and convincingly in oral and written English.
4. Acquaintance with some of the great masterpieces of literature and an understanding of their setting in and influence upon civilization.
5. Development of moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude.
6. Attainment of an interest and pleasure in these pursuits and thus of an inspiration to continued study.

freshman and sophomore years is presumed to provide a foundation for later study, but the work of the freshman and sophomore years should not be confused with the ordinary type of orientation course.

In the junior and senior years we classify the humanities and social studies under four major topics; namely, (1) Social Control, (2) Social Economy, (3) Social Ideas and Attitudes, and (4) Social Aspects of the Creative Arts. Classes are scheduled so that students pursue the study of problems related to one of these four major fields each semester. The sequence in which the student moves from one field to another in completing his junior and senior work is decided by the student in conference with advisers who counsel with him on his program prior to and at the time of registration for each successive semester. The limits within which the student makes his choice in any given semester are shown by the subheadings under the major topics for the junior and senior years on the chart accompanying this article. Each subheading is a "unit of instruction," or in more familiar terms, a "course," covering one semester. In the four semesters of the junior and senior years a student completes the study of four units, one each semester. Essentially the junior-senior units represent a group of students working on a series of problems related to a common topic of instruction covered by a study outline which has been prepared in advance by an instructional committee of staff members.

The procedure just described for juniors and seniors is that followed by the majority of students. For a limited group of students of outstanding ability, seminars and project work are provided. Students permitted to schedule seminars in the junior or senior years omit the study of units indicated under the four major junior-senior topics shown on the chart. The same holds true for senior students who are permitted to register for project work.

In project study, students work independently in seeking solutions to individually selected social or economic problems. A senior who displays interest and ability to carry on project study successfully is encouraged to do so because we feel that project work for able students is of paramount importance. Both interest and superior capacity for thoughtful study are essential to project work, because without them the student makes little headway, becomes discouraged, and dissipates the time of his faculty advisers.

The completion of a project is the individual responsibility of the student; however, for purposes of supervision, a series of conferences are scheduled for project students in groups of 10 to 15. These conferences, conducted under the direction of a staff member who acts as coördinator, provide opportunity for presentation of periodic reports and critical discussions of each other's work by members of the project group. A student pursuing project work is also required to confer with a staff member selected to act as adviser because of special knowledge in the field covering the topic selected by the student. An English adviser offers suggestions on the preparation of outlines, synopses, and reports.

Seminars have been conducted under the general headings: "Practices of Democracy," "National and International Planning," "Industrial Relations," "War and Postwar Problems." Seminars differ from individual project work in that groups of 10 to 15 students meet together, each making in-

Social Relations Program

COLLEGE OF ENGINEERING

CARNEGIE INSTITUTE OF TECHNOLOGY

FRESHMAN YEAR

First Semester	Second Semester
TECHNOLOGY AND SOCIETY	INTELLECTUAL TOOLS
1. Interpretation of the Social Relations Program	1. Language as a Tool
2. The Engineer's Place in Society	2. The Arts as Media of Expression
3. Relation of Science and Society	3. Measurement as a Tool
4. Background of This Machine Age	4. Methods of Thinking
5. Characteristics and Effects of the Machine Age	5. Scientific Thought and Society

Economic, Psychological, Political, Social, and Legal Concepts

SOPHOMORE YEAR

First Semester	Second Semester
PROBLEMS OF POPULATION	PROBLEMS IN NATURAL RESOURCES
1. Interaction of Man and Environment	1. Agricultural Way of Life
2. Man in Evolution	2. The Basic Resources of Industrialism
3. Racial Theory and Problems	3. The Urban Way of Life
4. Ethnic Elements in American Life	4. International Economy of Trade and Raw Materials
5. Population Theory, Trends, and Policies	

Economic, Psychological, Political, Social, and Legal Concepts

JUNIOR AND SENIOR YEARS

Each student selects one study unit each semester to provide a sequence of four

Study Units in Social Control	Study Units in Social Economy	Study Units in Social Ideas and Attitudes	Study Units in Social Aspects of the Creative Arts
A. Relation of Government to Society	A. Economic Organization of Society	A. Development of Social Ideas	A. Social Nature of Art
B. Codes and Legal Regulation	B. Industrial Relations	B. The Individual and Society	B. Literature of Social Significance

SEMINARS AND PROJECTS

SOCIAL RELATIONS SEMINARS. Junior or senior students who demonstrate special competency in the freshman and sophomore years are permitted to omit part of the sequence of "Unit Study" indicated above and register for a Social Relations Seminar. In these seminars 10 to 15 students study together and subdivide the task of analyzing specific problems related to a general problem or topic.

SOCIAL RELATIONS PROJECTS. A senior student who demonstrates ability to profit by such study is permitted to omit the last year of "Unit Study" and substitute therefor individual project study on a social or economic problem of his choice.

The program of study is administered under the supervision of the Social Relations Program Committee composed of staff members of the College of Engineering and the Division of Humanistic and Social Studies.

dividual studies of limited phases of a general topic; whereas, in individual project work, the problem selected by the student need not be related to problems under investigation by other students. Seminars are organized whenever it is found that a group of capable students are interested in problems which are related to each other. Thus the particular seminar or seminars available in any given semester may differ from those previously scheduled and from those which may later be arranged.

Text materials provided for students in the freshman and sophomore years include a series of carefully selected readings adapted from the writings of leading thinkers in the social aspects of technology and science and research specialists in the humanities and social sciences. Readings are grouped around the topics of study indicated in the chart outlining the program. These readings, which we publish, are supplemented by library assignments in standard textbooks on the history of civilization, government and politics, and political economy. Current magazine articles are occasionally assigned for class discussion.

The study of selected readings goes beyond the mere accumulation of information. The methods of instruction which we are evolving will, we believe, lead to the attainment of the objectives of the program. We seek to develop in the student the ability and desire to consider social and economic problems objectively. To this end he must learn to avoid emotional bias, professional self-interest, or cocksure preconception in social synthesis. The problems dealt with require mature thinking, often considerably more mature than the student may feel that he is able to achieve; and sometimes we are frankly convinced that in this respect the student is right. However, with the proper type of classroom leadership we believe that the student benefits by grappling with serious problems requiring him to reach above the level of ordinary social problem thinking.

As a contribution toward a high order of thinking we select instructors with extreme care and limit the size of sections to 20 students. The instructors in the freshman and sophomore years are chosen with a view to providing staff members who have sufficiently broad interests beyond their respective fields of specialization to be able to stimulate and direct student thought on social problems. Staff members are drawn from the departments of history, economics, psychology, mathematics, modern languages, and English of the Division of Humanistic and Social Studies and from various departments of the College of Engineering. Thus a staff member in English, one in history, one in economics, one in mathematics, and one in civil engineering may be teaching in the same unit of instruction. The fact that men of such diverse viewpoints join together in committee and conference groups to plan the conduct of a course is an educational achievement of no small significance in itself.

The same break-over in departmental lines occurs in the junior and senior years; for example, an instructor in history, one in psychology, and one in economics may each be teaching a different section of the same junior or senior unit of instruction. Here again the planning of instruction is determined in committee meetings and conferences among instructors. They confer on questions of subject matter, methods, reference assignments, and text material. In the upper years the

problem of obtaining suitable text materials is a difficult one. However, since students are likely to be scheduled in smaller numbers for any particular upper class unit than is true in the freshman and sophomore years, reference materials are more easily made available through our Social Relations Library.

While provision of study materials has been a major problem, it has not been our only problem. As with all educational innovations, gaining acceptance of the program by staff members of the Division of Humanistic and Social Studies and of the College of Engineering, accustomed to departmental isolation, and getting acknowledgement of the merits of the program from them has not always been easy—there are still a few who are skeptical and critical. Gaining acceptance by students and eliciting enthusiastic participation has presented a continuous problem in motivation. Recruiting and developing a staff of instructors from departments of the Division of Humanistic and Social Studies and from the staff of the College of Engineering is one which has required patience, tact, and broad administrative coöperation. Only a moronic optimist would say that these problems have all been satisfactorily solved—they have not, nor will they ever be wholly solved. But they have been solved to the extent that the program is operating with minor obstructions and friction points. There is but one answer to the question of how they have been solved, and that is leadership. The focal point of leadership has been the Maurice Falk Professor of Social Relations. Yet he would be the first to point to the many contributions in leadership that have come from various members of our staff working officially and unofficially, committee and conference groups, students, and administrative officials. To any other institution contemplating a similar experiment, our experience commends multiple leadership accompanied by the widest possible staff participation.

Our Social Relations Program, which occupies about 20 per cent of the instructional time in our various engineering curricula, represents, we believe, a major educational experiment, and should be judged as such. While we have given considerable thought to the planning and development of the program, have expended a great amount of time and money in the collection of instructional materials, and have held seemingly endless committee and staff meetings over a period of five years, we do not feel, by any means, that we have progressed beyond the experimental stage. Our president has recently said that, while he considered the experiment at its outset one which would require ten years, he believed we had, in the first five years, progressed about 70 per cent of the distance along the road we must travel to reach our goal. Some of our staff members who see imperfections at closer range feel that such an estimate is somewhat optimistic. Student opinions vary in their estimates from about 20 per cent to about 80 per cent achievement of the objectives of the program as a whole. These opinions give us a rough reckoning of the progress we must make in the next five years.

Using methods of measurement sufficiently refined for educational survey purposes we have tried to evaluate our attainment of the objectives set forth by the Committee on Aims and Scope of Engineering Curricula for the humanistic-social stem of engineering education. The results of an evalua-

tion study conducted more than a year ago indicated what might have been expected; namely, that certain of the objectives appear to be effectively implemented, others reasonably well attained, and others rather weakly observable in student accomplishment and student point of view. Likewise, some of the units of instruction appeared, as a result of the survey, to be ideally suited to the program; other units approached satisfactory status in varying degrees, while some of the units of instruction appeared to be suffering somewhat from limited perspective and overspecialization. Two of our original units of instruction have been withdrawn, some have been revised, and others are being revised at the present moment. Such modification and revision will continue as circumstances warrant.

We shall be obliged to await the return of more normal times to again evaluate our program in order to determine whether our efforts at improvement are bearing fruit. In the meantime we are carefully considering all suggestions for improvement, and we believe that progress is being made. With a continuance of enthusiasm displayed by staff members, with an intensification of effort by students, with further improvement of instructional methods and materials, and with a continuance of an experimental point of view we confidently anticipate that the optimum of perfection in the program will be reached in another five years.

S.P.E.E. Summer School for Teachers of Engineering Drawing, 1945

The Council of the Society, at its meetings in Cincinnati in June, 1944, approved a school for teachers of engineering drawing to be held in 1945 under the auspices of the Division of Engineering Drawing, S.P.E.E. The Chairman of this Division, Justus Rising, Purdue University, has sent the following letter to the deans of engineering and to the heads of engineering drawing asking for help in making plans:

The Proceedings of the Society contain the following articles concerning the previous program of summer schools for engineering teachers and numerous announcements and reports about particular schools are scattered throughout the *Proceedings* and THE JOURNAL OF ENGINEERING EDUCATION from 1926 to 1936. We hope to profit, and be guided by, the experience gained in these previous summer schools without necessarily being bound by it.

Vol. 34, 1927, pages 777–779—Summer Schools for Engineering Teachers, Their Aims and Methods, W. E. Wickenden.

Vol. 36, 1929, pages 109–129—The Summer School for Engineering Teachers, A Practical Step Toward Improved Methods of Teaching, H. P. Hammond.

Vol. 36, 1929, pages 693–694—Success of the Summer School, D. S. Kimball.

Vol. 39, 1932, pages 39–49—Report of Summer Schools for Engineering Teachers, H. P. Hammond.

I have always thought of my experience at the Pittsburgh school for drawing teachers in 1930 and the Madison school in 1936 as two of the most profitable in my twenty-five years as a drawing teacher. By the summer of 1945, fifteen years will have elapsed since the Pittsburgh meeting and nine since the Madison meeting and there have been numerous and important developments in the teaching of engineering drawing and in its application in engineering, in industry, and in government. Important changes in engineering education are coming, and drawing teachers should get together to take stock and determine how they can make the best contribution to engineering education in the days to come.

An early reply to the following questions will be deeply and sincerely appreciated and will aid the Drawing Division a great deal in starting the planning:

1. Should the school be planned for an industrial or a non-industrial community?

The 1930 Drawing School was held at the Carnegie Institute of Technology, Pittsburgh, Pa.; the 1929 Mechanical Engineering School at Purdue University, Lafayette, Ind., where there are practically no industries nearer than Indianapolis (60 mi.) and Chicago (140 mi.). The question of housing needs to be considered. Dormitory housing at Pittsburgh, with the "extracurricular" sessions, was a valuable feature.

2. What topics should be included in the program for presentation and discussion?

(A) The Pittsburgh outline contained the following topics: (a) Orientation of freshmen to engineering; (b) Relationship of the engineering drawing courses to the engineering curriculum; (c) Objectives of courses in drawing and descriptive geometry; (d) Standards for drawing and drafting room practice; (e) Content of an engineering drawing course; (f) Content of a descriptive geometry course; (g) Sectioning students on the basis of ability; (h) Aptitude tests and their use in sectioning students; (i) Use of recitation in teaching drawing; (j) Problem question: Source, presentation, laboratory methods; (k) Engineering college preparation for the industrial drafting room; (l) Use of recitation in descriptive geometry; (m) Use of laboratory period in descriptive geometry; (n) Demonstration classes in engineering drawing and descriptive geometry; (p) Responsibility of the drawing teacher; (q) Development of a course in engineering drawing; (r) History of the development of graphical representation; (s) Examinations and tests of achievement; (t) Drawing room design, equipment and appliances; (u) Committee reports.

(B) The Madison program contained the following topics: (a) What training in graphics does industry require of the young engineer? (1) Electrical engineering; (2) Mechanical engineering; (3) Civil engineering; (4) Other branches; (b) What type of training in freshman graphics is important to progress in the remaining period of engineering education? Electrical, mechanical, civil, other branches; (c) What qualities and special training are important to drawing teachers? (d) How best to meet the objectives of speed and skill in drawing courses? (e) Educational and cultural objectives in drawing courses; (f) Should instruction in graphics be carried beyond the freshman year? (g) Present day needs in the freshman drawing course; (h) Present day needs in freshman course in descriptive geometry; (i) To what extent are the teaching problems in high school and college curricula dependent or independent of each other in the field of drawing? (j) Do we need to teach the graphic language to engineering students? (k) Can drawing courses be made to serve as material for orientation, and for professional application? (l) Testing material—its purpose, types and uses (in a broad educational sense); (m) Class room teaching methods and special devices; (n) Laboratory methods and special devices; (o) Use of special equipment; (p) Films as an instructional medium and for correlation purposes.

(C) Some new topics which might be included are: (a) Use of visual aids; (b) Comprehensive examinations; (c) Technical institutes; (d) Correspondence courses; (e) War training courses; (f) Special programs for girls as industrial draftsmen; (g) Other?

3. What special procedures that would be interesting and/or valuable items for the program are used at your institution?

4. Whom on your staff would you suggest as one to take part in the program, and what topic would suit him best?

Please send us a list of your drawing staff with sufficient information about each one for us to select participants if

we do not receive enough specific suggestions and nominations.

5. Do you know of any speakers or topics outside of engineering institutions, in industry, or elsewhere who could contribute to the program and make it more effective?

6. Do you have any suggestions for the summer school that do not come within the scope of the five items above?

There will be a meeting of the Executive Committee of the Drawing Division in November to begin organizing our program for the summer school. Please let us have your suggestions at an early date and please make them as specific as possible.